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Trade Effect of a Single Currency in East Africa

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Trade Effect of a Single Currency in East Africa

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by
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ABSTRACT

The purpose of this study was to evaluate the effect of a single currency policy for Kenya, Tanzania and Uganda on the volume, value and direction of trade and the distribution of welfare changes between these countries. A single-commodity (maize), multi-country spatial equilibrium model was used to evaluate the possible trade and welfare effects of the proposed single currency. Simulation results show higher levels of aggregate regional production with increased production in Uganda and decreased production in Kenya and Tanzania. The results also show increased aggregate trade in the region, the value of exports from Uganda to Kenya increased by 12%, while export values from Tanzania to Kenya decreased by 25%. The results indicate that a single currency will result in a regional net welfare gain however the distribution of these gains will not be uniform across the region.

DEDICATION

I dedicate this work to my Dad, Joseph Mukwaya for all the love and for always supporting my dreams.

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CHAPTER ONE

INTRODUCTION

Kenya, Tanzania and Uganda have each adopted the export-led growth model as the main guide to national economic development and are implementing strategies for expanding their shares of the global export trade both in the traditional export destinations as well as regionally with each other. Strategies to increase intra-regional trade include elimination of trade barriers through a regional trade block, the East African Common Market, and a monetary union.

The purpose of this study is to evaluate the trade effect of a single currency policy for Kenya, Tanzania and Uganda. The study will increase our understanding of the economic impact of monetary union in East Africa as well as the distribution of benefits among member countries and the results will have important implications for monetary and trade policy formulation in the East African region.

There are several instances of monetary unions where two or more countries share a single currency, an arrangement alternately referred to as unitary or common currency. Examples of single currency unions include the East Caribbean dollar (Anguilla, Antigua and Barbuda, Dominica, Grenada, Montserrat, Saint Kitts and Nevis, Saint Lucia, and Saint Vincent and the Grenadines), the CFA[1] franc BEAC[2] (Cameroon, Central African Republic, Chad, Republic of

[1] CFA (*Coopération financière en Afrique centrale)* "Financial Cooperation in Central Africa".
[2] BEAC (*Banque des Etats de l'Afrique Centrale*,) "Bank of Central African States".

the Congo, Equatorial Guinea and Gabon), the CFA franc BCEAO[3] (Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo), the CFP franc (French Polynesia, New Caledonia, and Wallis and Futuna), the Euro (Austria, Belgium, Cyprus, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, Slovenia, Spain and Monaco, San Marino, and the Vatican City).

Other *de facto* monetary unions where a country uses a foreign currency in parallel to or instead of the domestic currency (dollarization) include the Armenian dram (Armenia and Nagorno-Karabakh Republic), the Australian dollar (Australia, Kiribati, Nauru, and Tuvalu), the Euro (Andorra, Kosovo and Montenegro), the Indian rupee (India and Bhutan), the New Zealand dollar(New Zealand, Niue, the Cook Islands, Tokelau, and the Pitcairn Islands), the Israeli new shekel (Israel and Palestinian territories), the Russian ruble (Russia , Abkhazia and South Ossetia), the South African rand (South Africa, Swaziland, Lesotho, and Namibia), the Swiss franc (Switzerland and Liechtenstein), the United States dollar (United States, Palau, Micronesia, Marshall Islands, Panama, El Salvador, British Virgin Islands, Turks and Caicos Islands).

And currently there are several planned monetary unions that include the East African Community, West African Monetary Zone within the Economic Community of West African States (ECOWAS), the Caribbean Single Market and Economy (CSME) (as part of the CARICOM), Union of South American Nations (Unasur/Unasul), the Common Market for Eastern and Southern Africa, and the African Economic Community.

[3] BCEAO (*Banque Centrale des États de l'Afrique de l'Ouest*,) "The Central Bank of West African States".

Finally, there are proposed monetary unions for China, Japan and South Korea (Asian Currency Unit) and the Amero for Canada, the United States and Mexico as well as one for Australia, New Zealand and Papua New Guinea.

The East African monetary union that will include Burundi, Kenya, Rwanda, Tanzania and Uganda is one of the stages in the East African economic and political integration process. Kenya, Tanzania and Uganda have a long history of institutional and economic cooperation which fostered an environment with high rate of labor mobility at professional, managerial, skilled and unskilled levels; and capital mobility in the service industry (banking, insurance, transportation and tourism) as well as manufacturing and mining.

Theoretical Model

The positive trade effect of a single currency scenario is attributable to movement from one market equilibrium point to another due to adjustments to exchange rate free economic environment. Consider a single homogenous product produced in two regions, X and Y (Fig.1.1). In region X, market equilibrium is at price P_j and quantity Q_j and in region Y, market equilibrium is at price P_k and quantity Q_k, the equilibrium price in region X is greater than the equilibrium price in region Y.

With trade between region X and region Y, excess supply in region Y is exported to region X at the spatial equilibrium price P_A. Fig. 1.1 shows the domestic and spatial equilibrium prices in regions X and Y given unit transfer cost (T) and unit transaction cost (Z). The equilibrium price in importing region X is greater than equilibrium price in exporting region Y,

by the amount, T+Z, such that $P_j = P_k + T + Z$. The volume of trade is equal to the quantity exported from region Y, (Q_3Q_4) and the quantity imported to region X (Q_1Q_2).

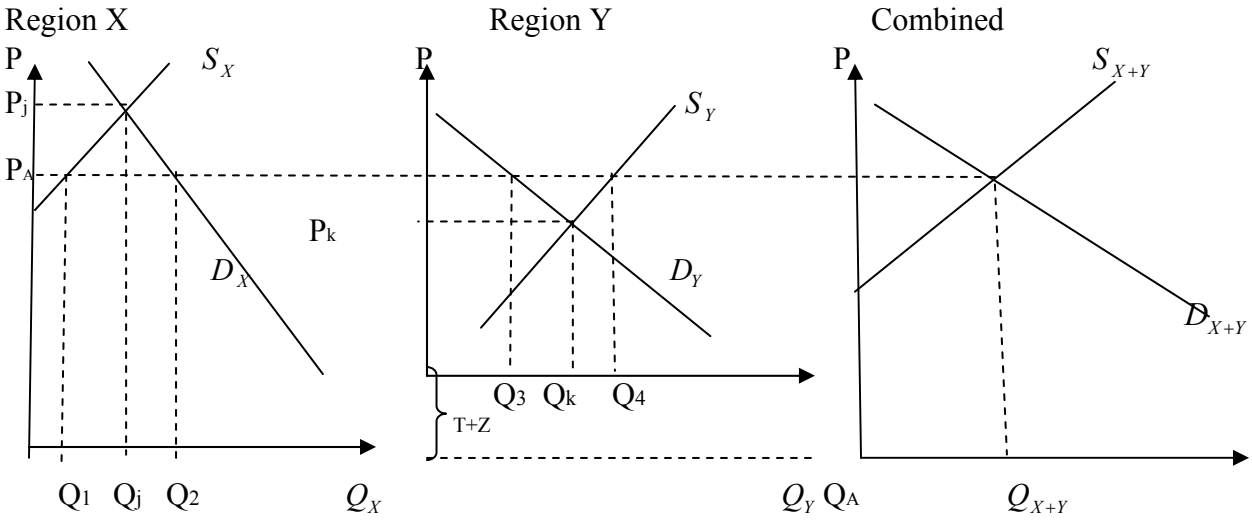

Figure 1.1 Spatial Price Equilibrium with Transfer and Transactions Costs
Source: Adapted from Bressler and King (1974).

Fig. 1.2 shows a new price and trade equilibria without transactions costs. The equilibrium price in importing region X is greater than equilibrium price in exporting region Y, by the amount, T, such that $P_j = P_k + T$. The new trade equilibrium is characterized by higher excess supply in region Y, Q_7Q_8, higher trade (imports to region X) and lower spatial equilibrium price. The increase in the trade volumes between the two regions depends on the demand and supply elasticities.

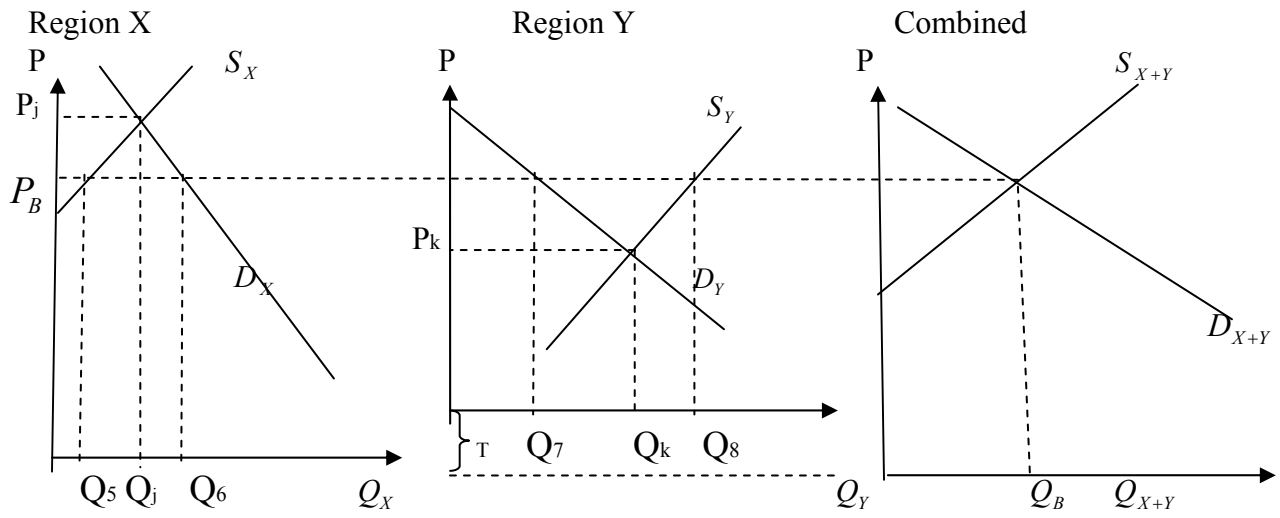

Figure 1.2 Reduced Transaction Costs
Source: Adapted from Bressler and King (1974).

Elimination of transactions cost reduces price risks associated with changes in the prices of imported inputs as well as exported commodities and has potential positive trade effects. In the present case, a monetary union eliminates exchange rate embedded costs leading to positive trade effect. Following Just et al., (2004), we consider a risk-averse producer in a competitive market with random product price P and price expectation $\mu_P = E(P)$. The output has no effect on product price distribution. Suppose that the firm makes short-run decisions by maximizing a mean-variance expected utility function

(1) $E[U(\pi)] = E(\pi) - \beta Q^2\sigma^2/2$

(2) $E[U(\pi)] = \mu_P Q - w_1x_1 - .....w_nx_n - c_o - \beta Q^2\sigma^2/2$

Where U is the utility, π is profit, Co is fixed cost, x_i is quantity of factor input i, w_i is the input price associated with x_i, β is the absolute risk aversion parameter and σ^2 is variance of price, $\sigma^2 = E(P - \mu_P)^2$. Thus $Q^2\sigma^2$ is variance of profit. Suppose minimum cost required to produce each unit of output is given by $C(Q)$, so that

(3) $E[U(\pi)] = \mu_P Q - C(Q) - \beta Q^2\sigma^2/2$

where $\beta Q^2\sigma^2/2$ is referred to as risk premium associated with output price uncertainty, from the first order conditions

(4) $\mu_P = C'(Q) + \beta Q\sigma^2$,

where $C'(Q)$ represents marginal cost, $\beta Q\sigma^2$ is a marginal risk premium. Now consider the case where the firm is risk-averse but faces no risk, equation (1) is reduced to

(5) $E[U(\pi)] = E(\pi)$, *or*

(6) $E[U(\pi)] = \mu_P Q - C(Q)$

Because $\sigma^2 = 0$.

Fig. 1.3 shows the effect of price risk on supply curves and market equilibria. $S_{X+Y}(\sigma^2)$, represents the supply curve of a risk-averse firm facing price risk, $S_{X+Y}(0)$, represents the supply curve of a risk-averse firm facing no price risk. Eliminating the price risk results in new market equilibrium, the market price adjusts to a lower price (from P_C to P_D) and the quantity supplied adjusts to a higher quantity (from Q_C to Q_D).

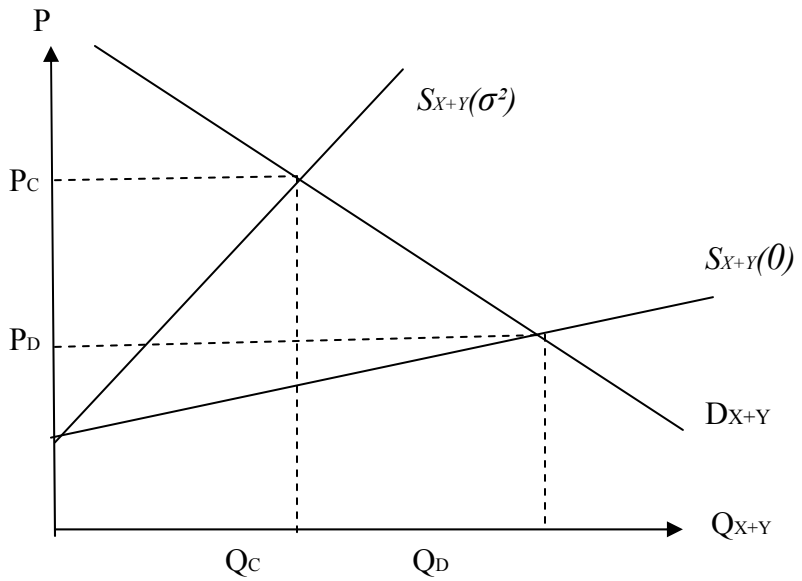

Figure 1.3 Effect of Price Risk on Supply Curves and Market Equilibria
Source: Adapted from Just et al., (2004).

Organization of the Study

The rest study is organized as follows, the background on regional economy in chapter two and a review of the literature in chapter three. Chapter four presents the data, empirical models and methodology of the study. Chapter five contains the results, conclusion and policy implications of the study.

CHAPTER TWO

BACKGROUND

The population level (Table 2.1), composition of GDP and labor force profile (Table 2.2) and the growth rates of GDP (Figure 2.1), show important structural similarities and differences. Regional resource endowments as well as the economic structure and income levels show that the region has great market and economic potential which can be realized through regional cooperation. The East African market has a size of 93 million people with high average regional growth rates in GDP (6% in 2006) leading to an increasing need for capital goods, improved infrastructure and improved technologies in the East African market.

Table 2.1 Population Level and Distribution: Kenya, Tanzania and Uganda, 2006

		Kenya	Tanzania	Uganda
Population				
	Total (#)	32,499,100	34,827,600	25,474,700
	Share (%)	35. 0	37.5	27.5
Area (Sq.km)				
	Total	582,650	945,087	236,040
	Land	569,250	886,037	199,710
	Water	13,400	59,050	36,330
GDP				
	Total (US$B)	41	30	53
	Per capita (US$)	1,200	800	1,900
	Growth rate (2005-06)	6	5.9	5

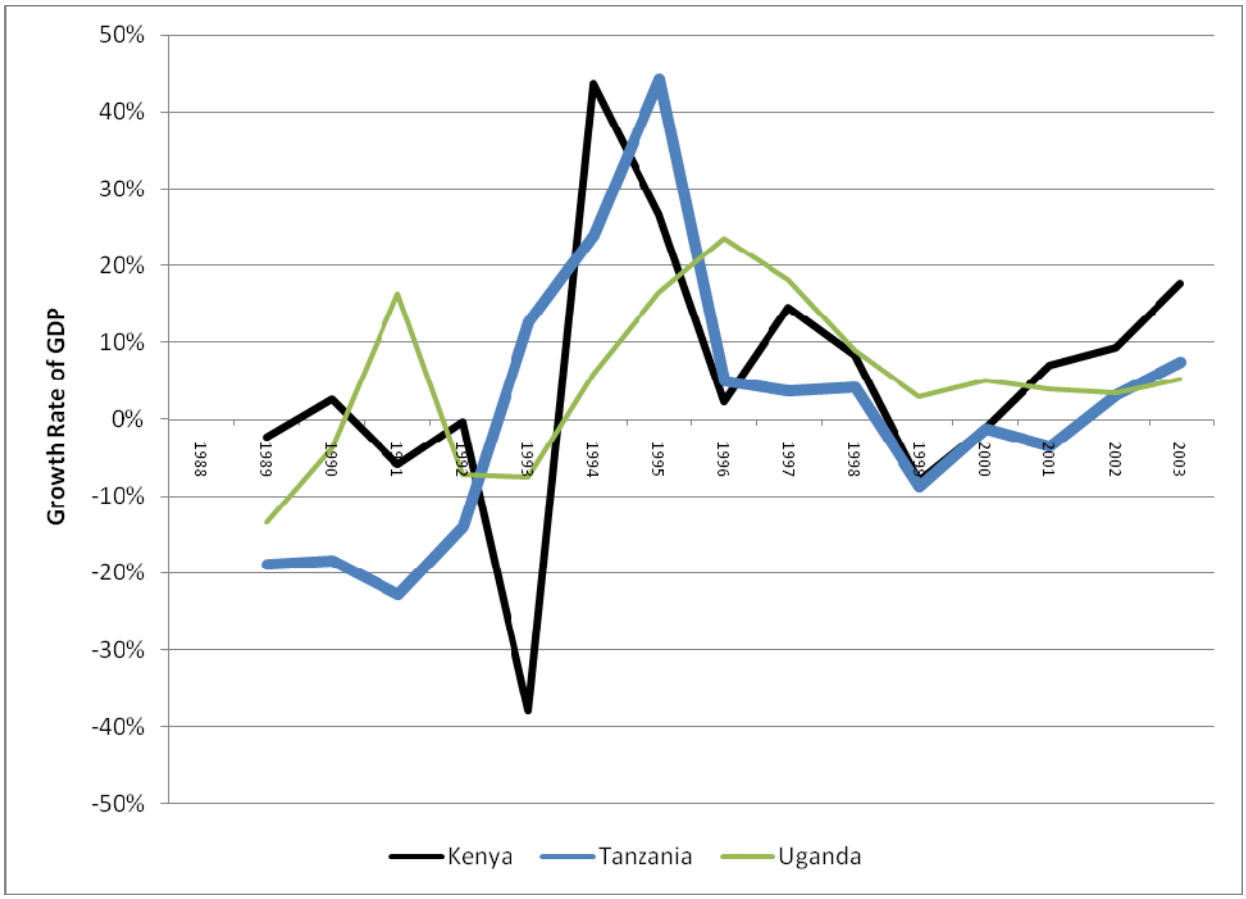

Figure 2.1 Growth Rate of Gross Domestic Product for Kenya, Tanzania and Uganda, 1988 - 2003

Table 2.2: The Composition of GDP and Labor Force Profile, Kenya, Tanzania and Uganda, 2006

Sector	Kenya	Tanzania	Uganda
Agriculture (% GDP)	24.1	43.2	31.4
Manufacturing (% GDP)	16.7	18.1	24.6
Services(% GDP)	59.2	38.7	44.1
Labor force			
Total(Million)	21.9	19.4	13.6
Agriculture (%)	75.0	80.0	82.0
Industry (%)	20.0	12.0	5.0
Services (%)	5.0	8.0	13.0

Kenya had a commanding share of intra-regional export trade with Uganda as the leading export destination accounting for 17.9% of the Kenyan global exports in 2006 (Table2. 3). Tanzania had the lowest intra-regional exports, with 4% share of her total exports to Kenya and 0.6% to Uganda, while Uganda had a bigger share of intra-regional exports than Tanzania with 9.1% share of her total exports to Kenya and 1.9% to Tanzania.

Table 2.3: Intra-Regional Trade Pattern: Bilateral Exports of Kenya, Tanzania and Uganda, 2006

Origin	Destination	Value ($ 000,000)	Share
Kenya	Uganda	31,186.4	17.9%
Kenya	Tanzania	21,206.3	12.2%
Tanzania	Kenya	33,968.0	4.0%
Tanzania	Uganda	5,300.0	0.6%
Uganda	Kenya	72,251.0	9.1%
Uganda	Tanzania	15,259.0	1.9%

The Kenyan export trade was relatively more concentrated than Tanzanian and Ugandan export trade in 2006. The top five trading partners accounted for 72.6% of total Kenyan exports in contrast with 61.9% for Tanzania and 47.7% for Uganda. The composition as well as export shares of the leading five trading partners export were variable (Table 2.4). The Kenyan export

shares of the five leading trading partners ranged from 17.9% (Uganda) to 12.2 (Tanzania). The Tanzania export shares of the five leading trading partners ranged from 18.3% (United Kingdom) to 6.1% (Netherlands), the Ugandan export shares of the five leading trading partners ranged from 10.8% (Netherlands) to 7.6% (Democratic Republic of the Congo).

Table 2.4: Global Export Concentrations: Kenya, Tanzania and Uganda, 2006

Origin	Destination	Export Shares (%)	
		Actual	**Cumulative**
Kenya	Uganda	17.9	17.9
Kenya	United Kingdom	17.2	35.1
Kenya	Netherlands	13.1	48.2
Kenya	USA	12.2	60.4
Kenya	Tanzania	12.2	72.6
Tanzania	United Kingdom	18.3	18.3
Tanzania	France	17.3	35.6
Tanzania	Japan	10.9	46.5
Tanzania	India	7.3	53.8
Tanzania	Netherlands	6.1	61.9
Uganda	Netherlands	10.8	10.8
Uganda	UAE	10.7	21.5
Uganda	Switzerland	9.5	30.9
Uganda	Kenya	9.1	40.1
Uganda	D. R. Congo	7.6	47.7

There are similarities in levels of foreign trade and the current account profiles for Kenya, Tanzania and Uganda, foreign trade constitutes an important component of GDP in all the three countries (Figure 2.2) and the current account profiles (Figure 2.3) show that the three countries are net importers of goods and services.

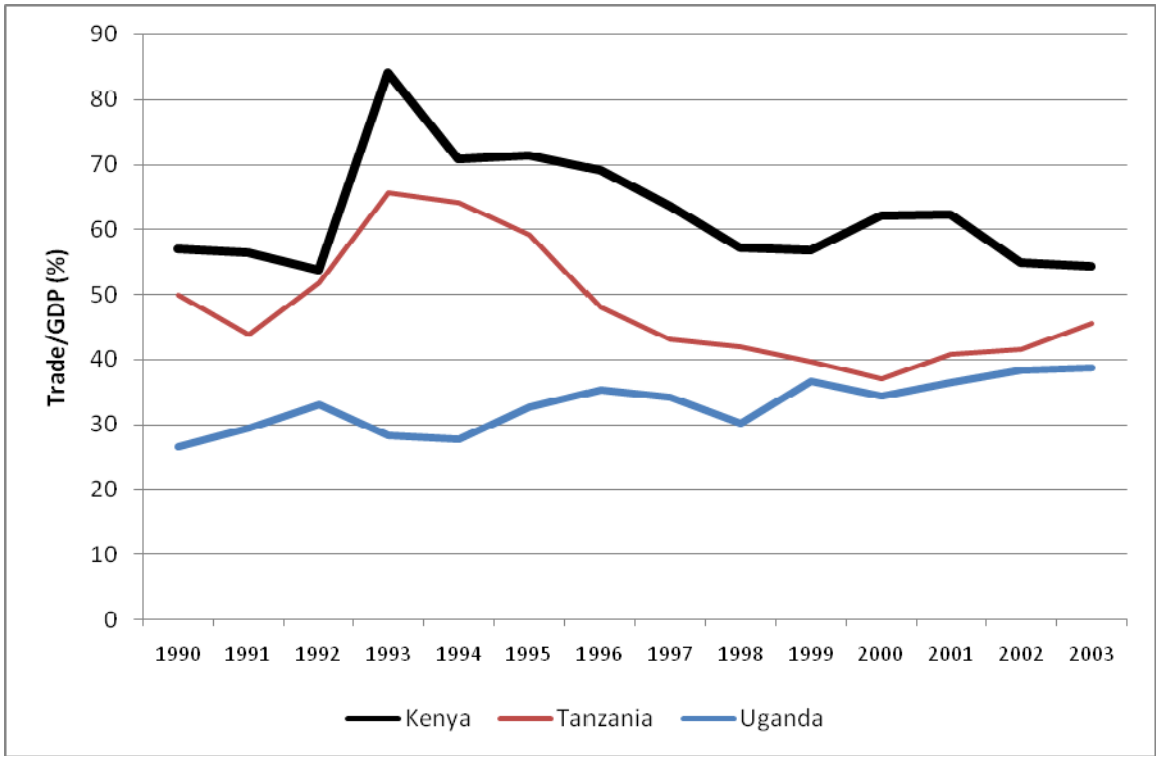

Figure 2.2 Trade (Imports and Exports) as Percentage of Gross Domestic Product for Kenya, Tanzania and Uganda, 1990 - 2003

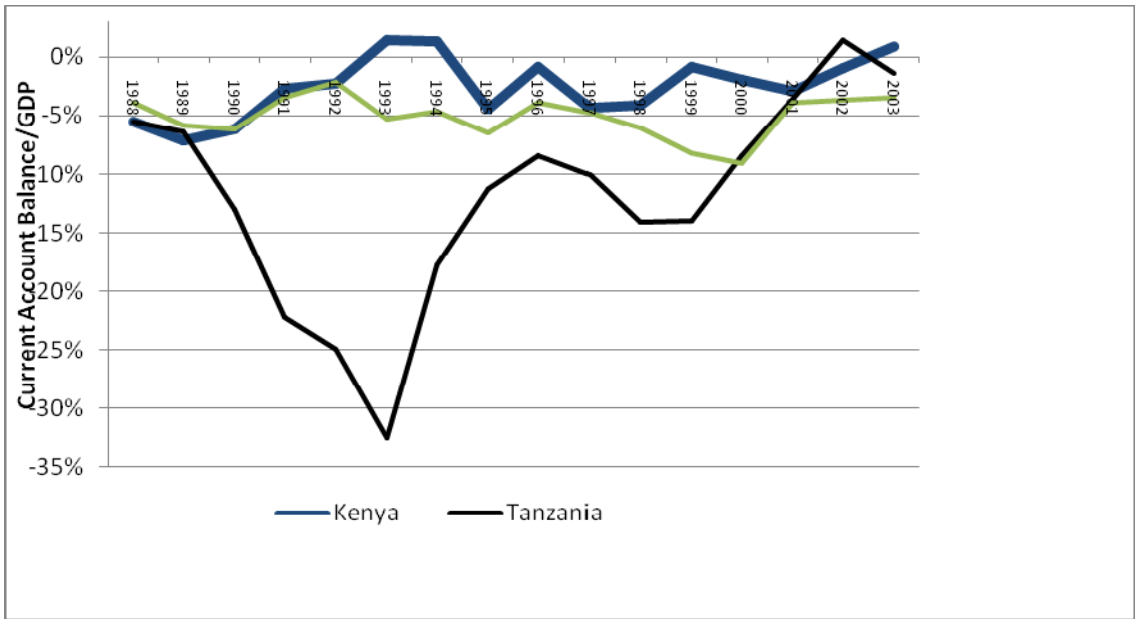

Figure 2.3 Current Account Balance as Percentage of Gross Domestic Product for Kenya, Tanzania and Uganda, 1990 - 2003

Foreign Exchange Markets in Kenya Tanzania and Uganda

This section provides a brief account of the relative value, volatility and stability of the Kenya shilling, Tanzania shilling and Uganda shilling. The national currency of each of the three countries is freely convertible and exchangeable in the international market at market determined rates. The three currencies exhibit features that are characteristic of common underlying market and institutional mechanisms. The relative value, volatility and stability of the Kenya shilling, Tanzania shilling and Uganda shilling suggest that there is a degree of monetary policy harmonization among the three countries.

The three currencies have different purchasing power parities as indicated by the official exchange rates. We compare the values of the East African shillings using purchasing power parity theory, which is defined as

$$P = EP^*$$

Where E is the nominal exchange rate; P is the price of domestic goods and P^* is the price of foreign goods. That means that a bundle of goods should cost the same in two countries once the exchange rate is taken into account. The purchasing power parity theory uses the long-term equilibrium exchange rate of two currencies to equalize their purchasing power (Cassel, 1920).

Based on the law of one price, the concept of purchasing power parity underlies the notion that identical goods must have only one price in an efficient market. This can be applied to compare the values of the East African currencies based on their exchange rates with the U.S. dollar, the euro or any other currency. The values of the East African currencies relative the U.S. dollar and euro are reported in Figs. 2.4 and 2.5, respectively; and the values of the Tanzanian and Ugandan shilling relative to the Kenyan shilling are in Fig.2.6. Similarly, the values of the Kenyan and Ugandan shilling relative to the Tanzanian shilling, and the values of the Kenyan shilling and Tanzanian shilling relative to the Ugandan shilling are in Figs. 2.7 and 2.8, respectively.

The exchange rates of the East African currencies relative to the U.S. dollar (Fig. 2.4) and the euro (Fig. 2.5) show that the Kenyan shilling had the highest value and Uganda shilling the lowest value with the Tanzanian shilling in between. In the same manner, the value of the Tanzanian shilling was higher than the Ugandan shilling relative to the Kenyan shilling (Fig. 2.6) and the value of the Kenyan shilling was higher than value of the Ugandan shilling relative to the Tanzanian shilling (Fig. 2.7). Similarly, the value of the Kenyan shilling was higher than value of the Tanzanian shilling relative to the Ugandan shilling (Fig. 2.8).

The purchasing power parity measures of values of the East African currencies (Fig. 2.4 – 2.8) provide evidence that ranks the value of the Kenyan shilling highest, Ugandan shilling lowest and Tanzanian shilling in between throughout the sample period and currencies.

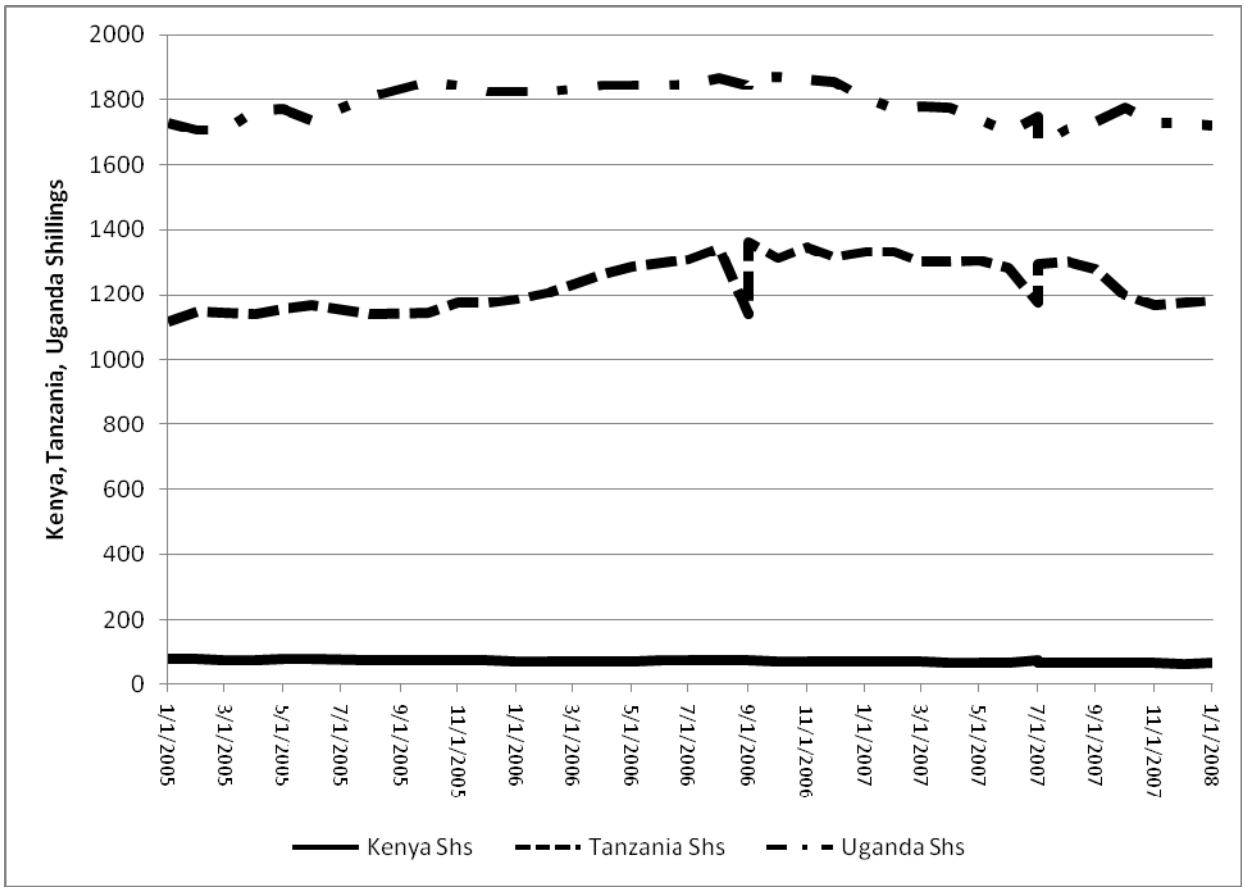

Figure 2.4 Kenya Shilling - U.S. Dollar, Tanzania Shilling - U.S. Dollar and Uganda Shilling - U.S. Dollar Exchange Rates: January, 2005 - December, 2007

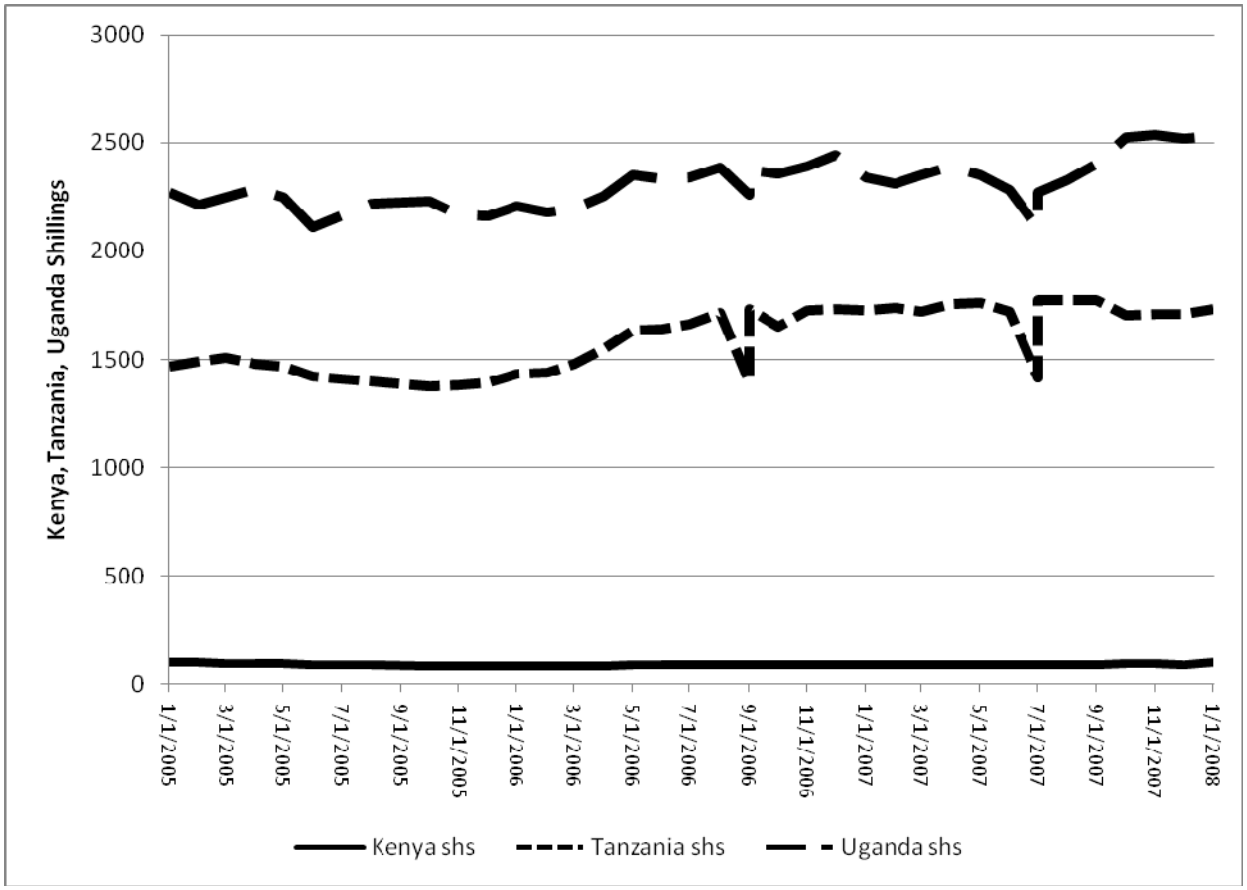

Figure 2.5 Kenya Shilling - Euro, Tanzania Shilling - Euro and Uganda Shilling - Euro Exchange Rates: January, 2005 - December, 2007

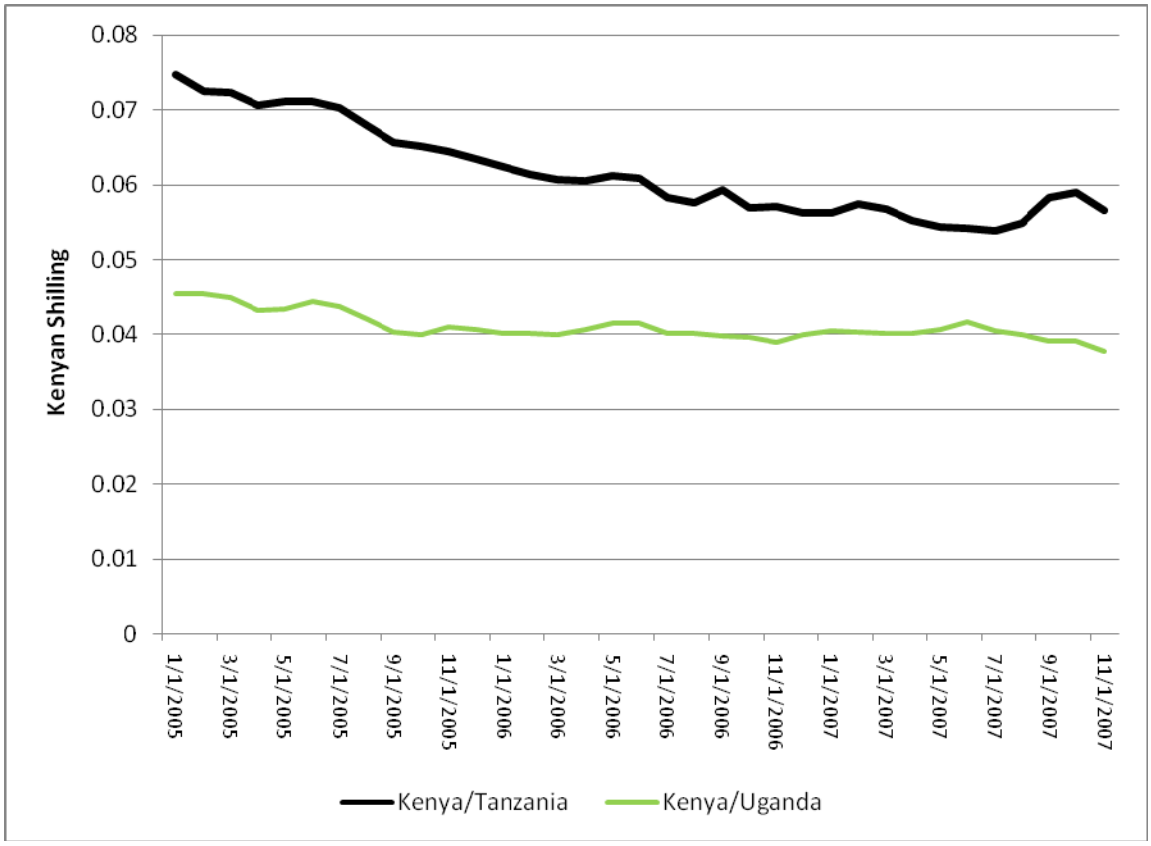

Figure 2.6 Tanzania Shilling - Kenya Shilling and Uganda Shilling - Kenya Shilling Exchange Rates: January, 2005 - December, 2007.

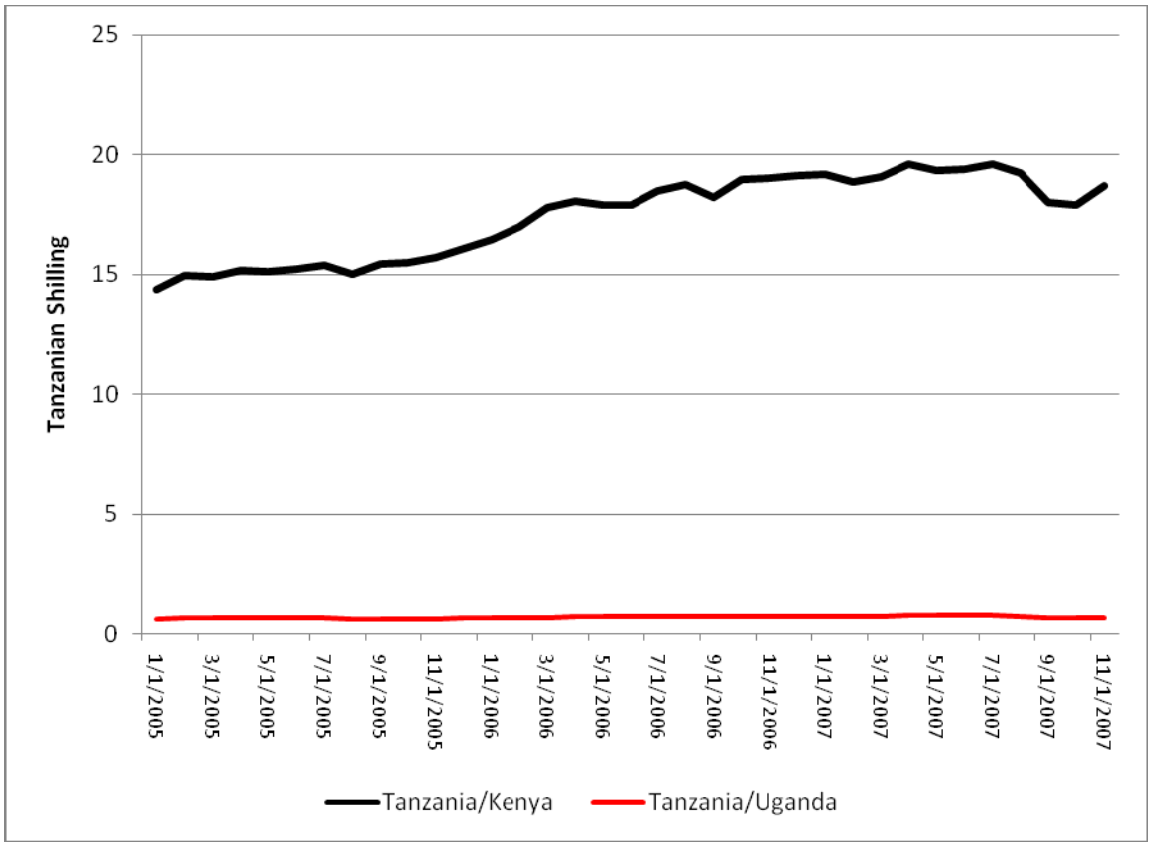

Figure 2.7 Kenya Shilling - Tanzania Shilling and Uganda Shilling - Tanzania Shilling Exchange Rates: January, 2005 - December, 2007

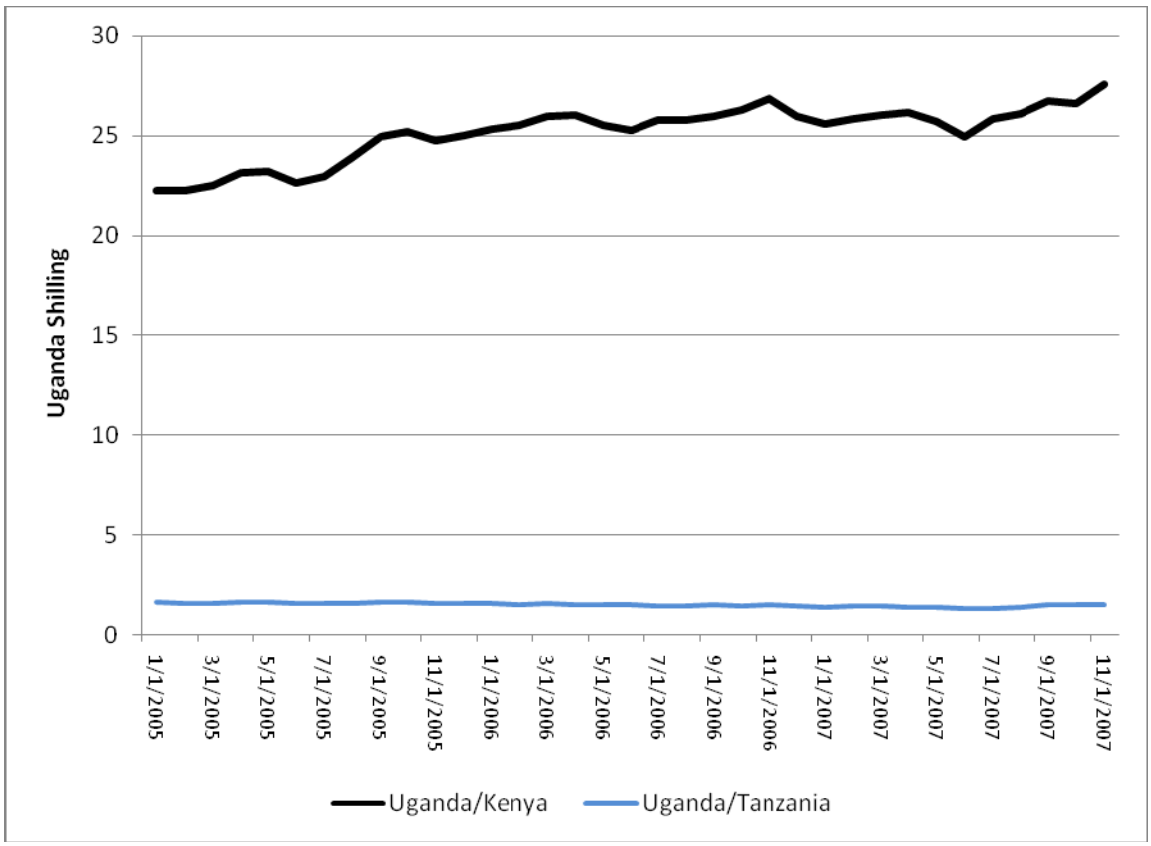

Figure 2.8 Kenya Shilling - Uganda Shilling and Tanzania Shilling - Uganda Shilling Exchange Rates: January, 2005 - December, 2007

We use the concept of inter-temporal price equilibrium to indicate the relative stability of the Kenya shilling, Tanzania shilling and Uganda shilling in the adjustment process following a deviation from the equilibrium exchange rate. Chiang (1974) has shown that given a time path P(t) and equilibrium price $\overline{P}$, an equilibrium is dynamically stable if the time path P(t) tends to converge to $\overline{P}$ as $t \to \infty$, an equilibrium is unstable if the time path P(t) tends to diverge away from the equilibrium $\vec{P}$ as $t \to \infty$. We use the first differences of exchange rates to illustrate the stability of the Kenya shilling, Tanzania shilling and Uganda shilling relative to the U.S. dollar, (Figure 2.9), the euro (Figure 2.10) as well as the Tanzania shilling and Uganda shilling relative to the Kenya shilling (Figure 2.11), the Kenya shilling and Uganda shilling relative to the

Tanzania shilling (Figure 2.12) and the Kenya shilling and Tanzania shilling relative to the Uganda shilling (Figure 2.13).

The first difference of the member country exchange rates with two major currencies, the U.S. dollar, the euro and, as applicable, with the Kenya shilling, the Tanzanian shilling and the Uganda shilling oscillate around zero but with varying directions and magnitudes. The oscillations around zero indicate the relative stability of the Kenya shilling, Tanzania shilling and Uganda shilling.

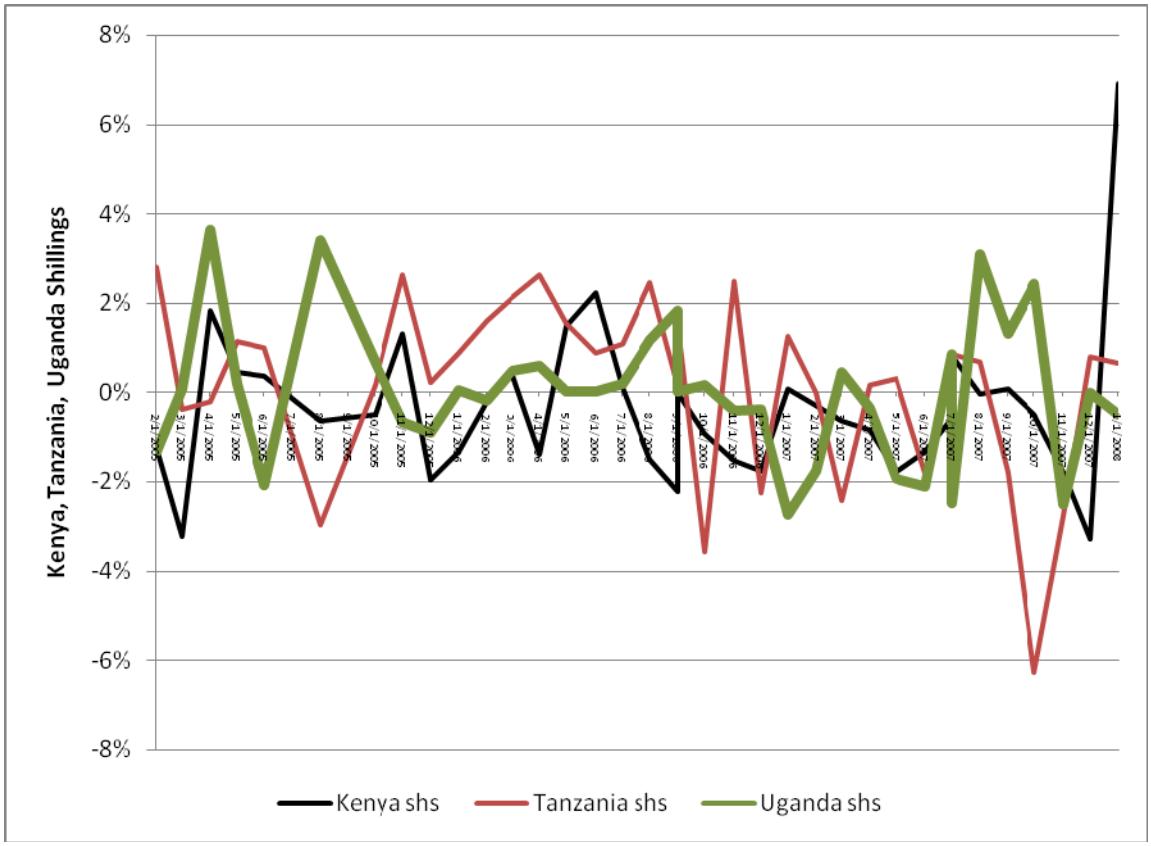

Figure 2.9 Kenya Shilling - U.S. Dollar, Tanzania Shilling - U.S. Dollar and Uganda Shilling - U.S. Dollar: First Differences, January, 2005 - December, 2007

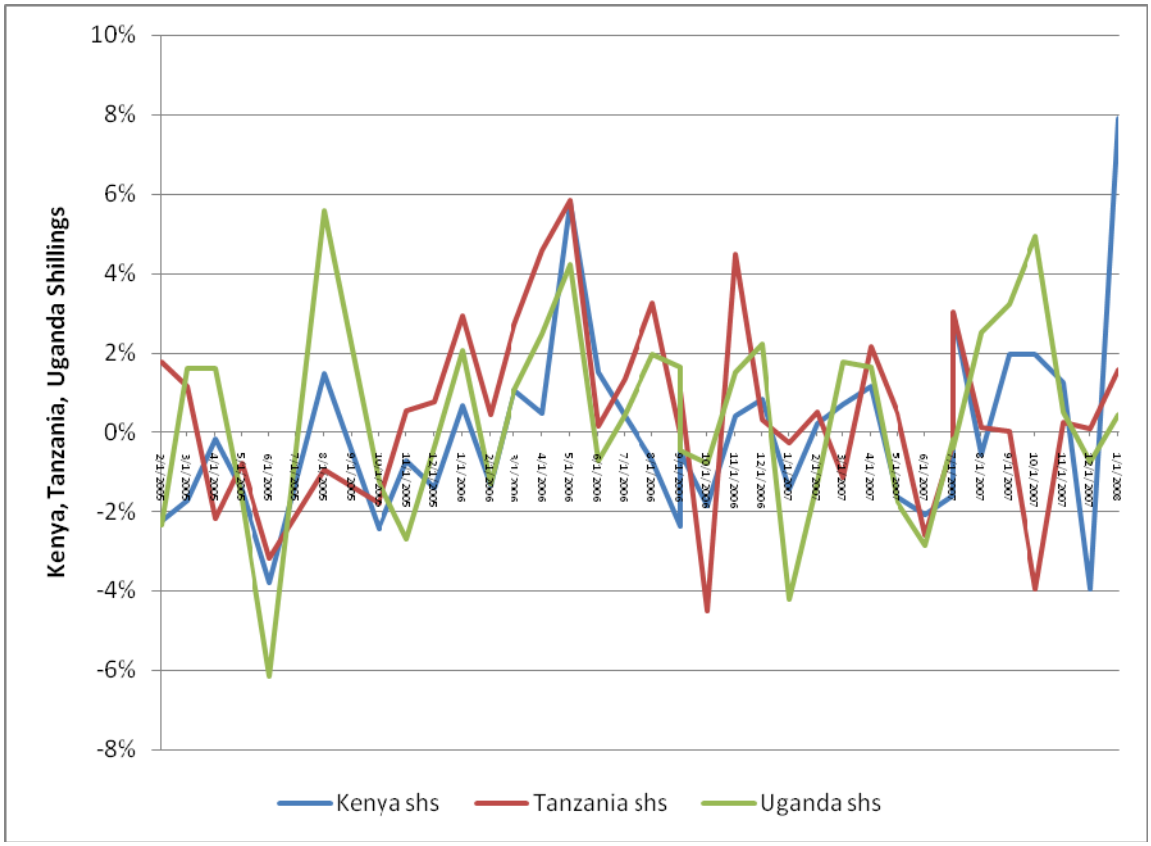

Figure 2.10 Kenya Shilling - Euro, Tanzania Shilling - Euro and Uganda Shilling - Euro: First Differences, January, 2005 - December, 2007

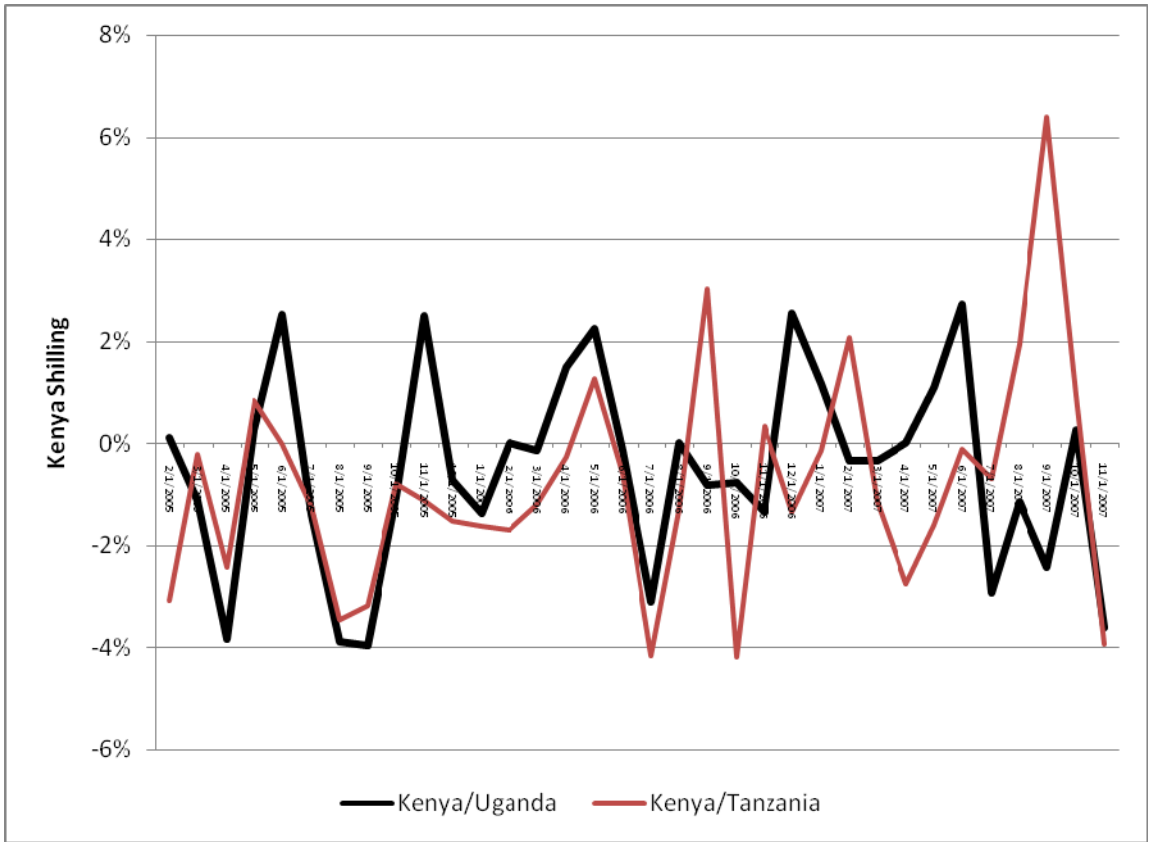

Figure 2.11 Tanzania Shilling - Kenya Shilling and Uganda Shilling - Kenya Shilling: First Differences, January, 2005 - December, 2007.

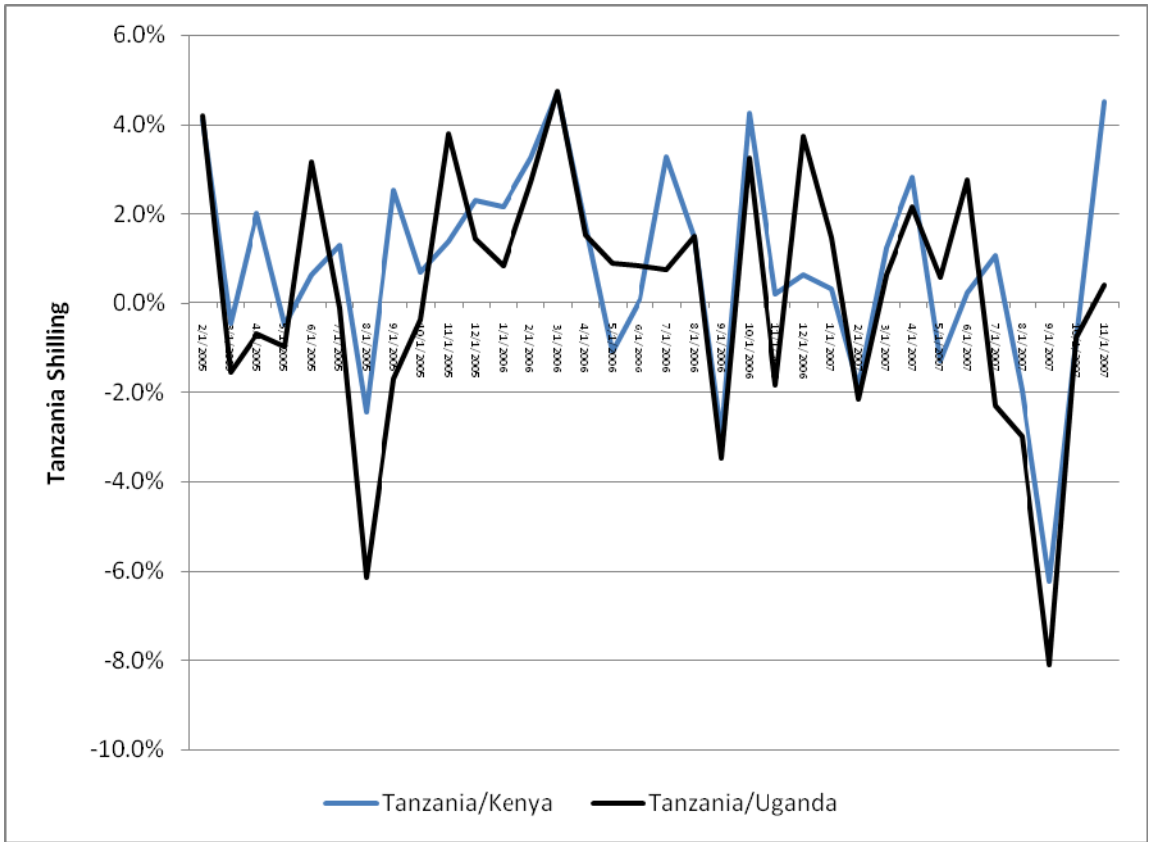

Figure 2.12 Kenya Shilling - Tanzania Shilling and Uganda Shilling - Tanzania Shilling: First Differences, January, 2005 - December, 2007

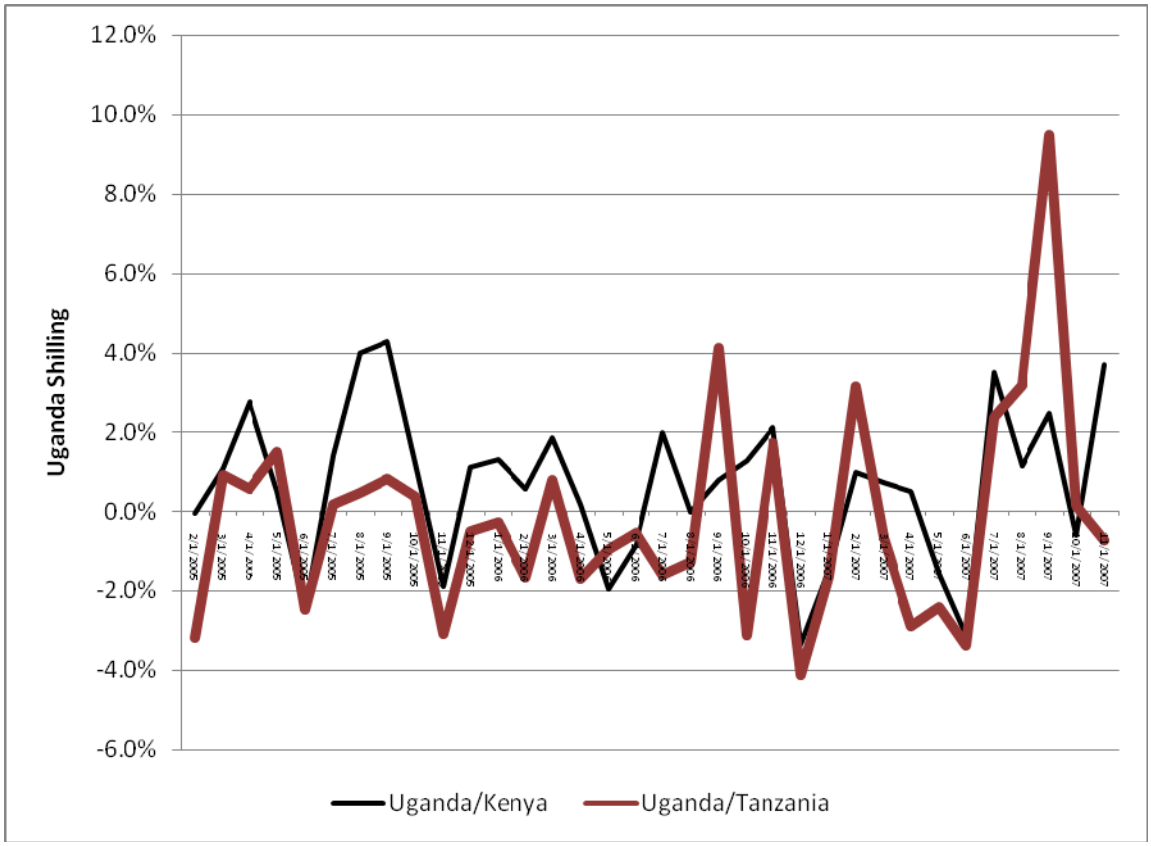

Figure 2.13 Kenya Shilling - Uganda Shilling and Tanzania Shilling - Uganda Shilling: First Differences, January, 2005 - December, 2007.

The third aspect of the Kenya shilling, Tanzania shilling and Uganda shilling we considered was the volatility as indicated by the magnitude of weekly changes in exchange rates attributable to changes in supply and demand in the foreign exchange market and possibly some non-market forces. We use a measure of exchange rate volatility used by Tenreyro (2004). Exchange rate volatility between countries i and j in year t, δ_{ijt}, is measured as the standard deviation of the first difference of the logarithm of the monthly exchange rate between the two countries, ($e_{ijt,}$) during the sample period.

δ_{ijt} = Std.Dev. [ln($e_{ijt,}$)− ln($e_{ijt-1,}$)]

When $\delta_{ijt} = 0$, there is no exchange-rate variability.

Volatility measures of the member country exchange rates with two major currencies, the U.S. dollar and the euro are shown in Fig. 2.14 and Fig. 2.15 and, as applicable, with the Kenya shilling the Tanzanian shilling and the Uganda shilling in Fig. 2.16, Fig. 2.17 and Fig. 2.18. Values of the exchange rate volatility range from 0.05 - 0.004, which indicates low levels of exchange rate variability.

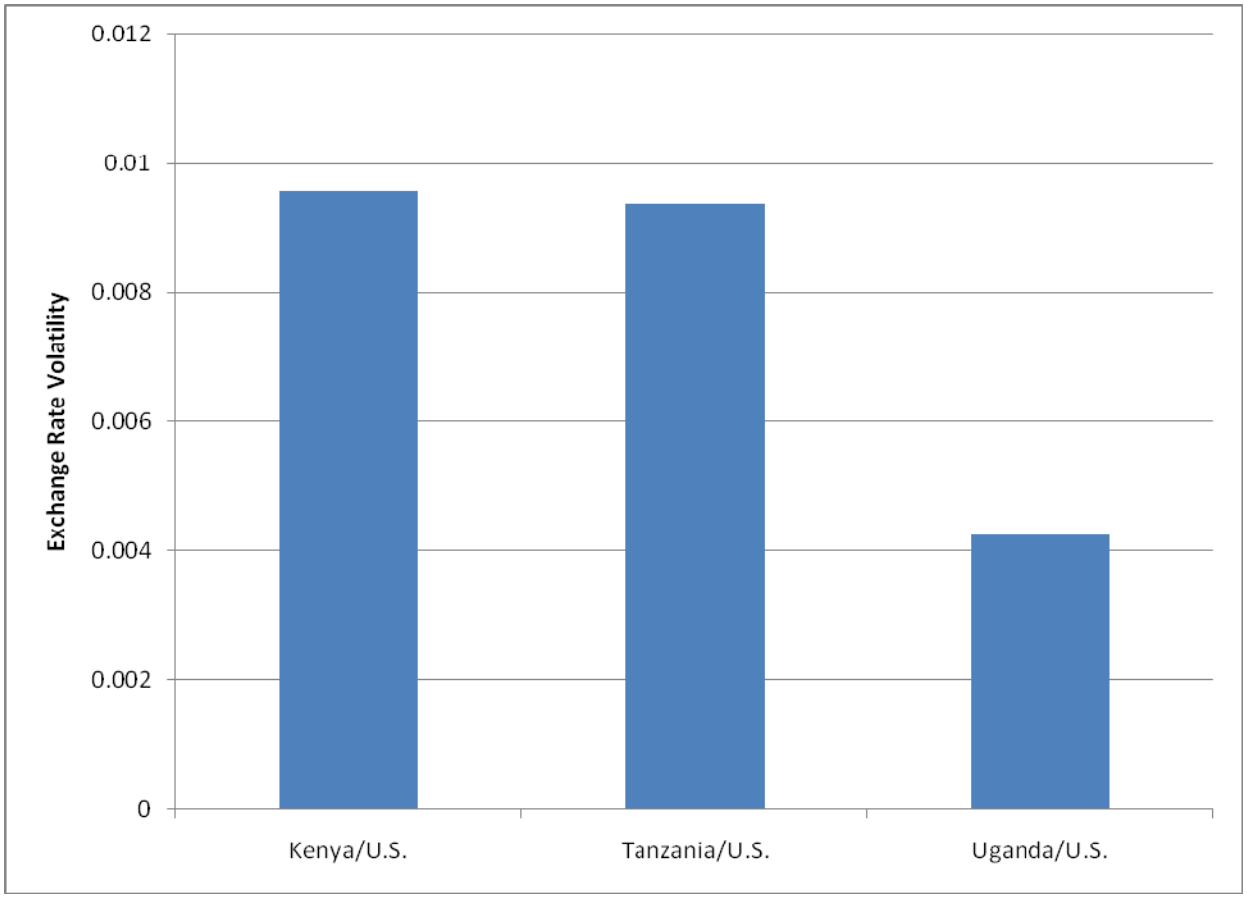

Figure 2.14 The Exchange Rate Volatility - Kenya, Tanzania, and Uganda Shillings Versus the U.S. Dollar, January 2005 - December 2007

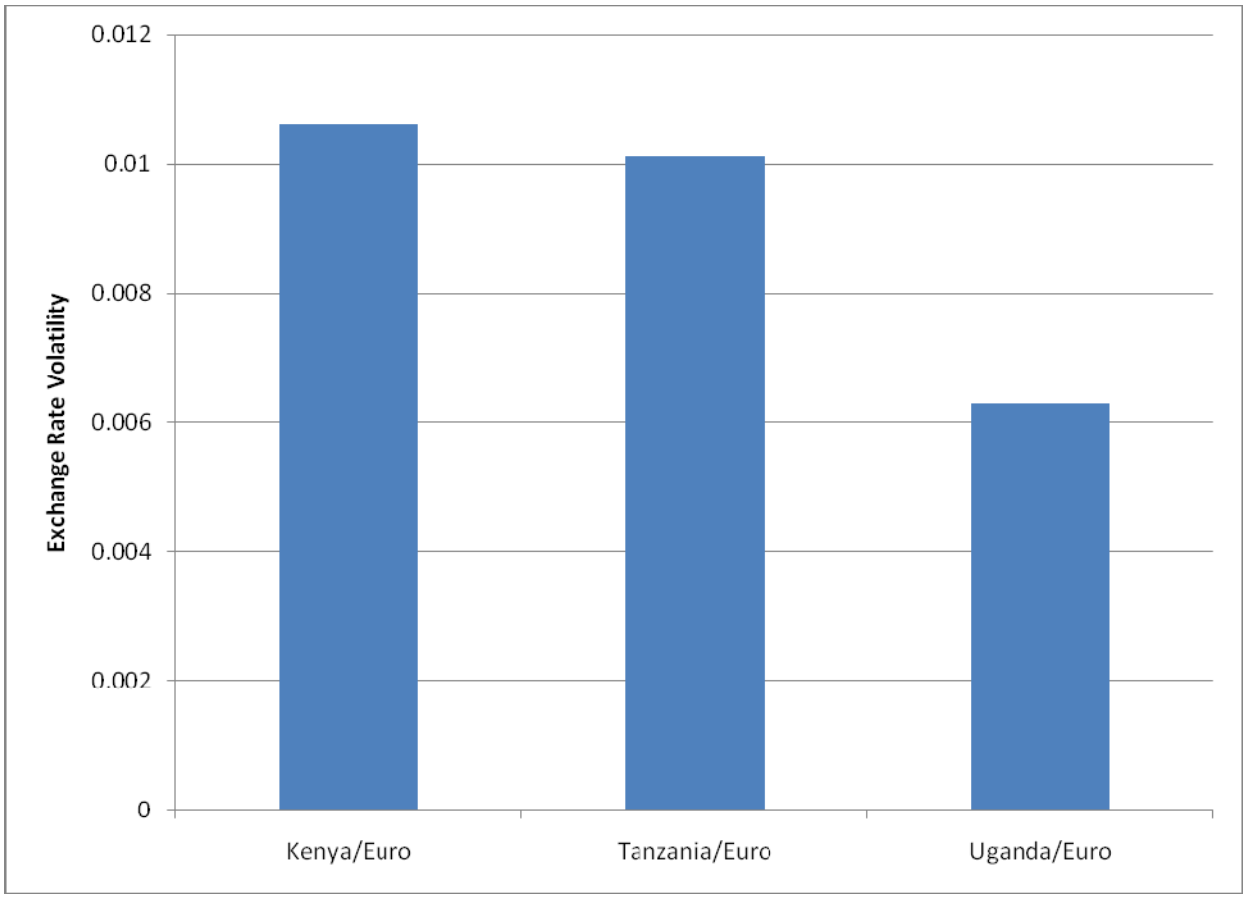

Figure 2.15 The Exchange Rate Volatility - Kenya, Tanzania, and Uganda Shillings Versus the Euro, January 2005 - December 2007

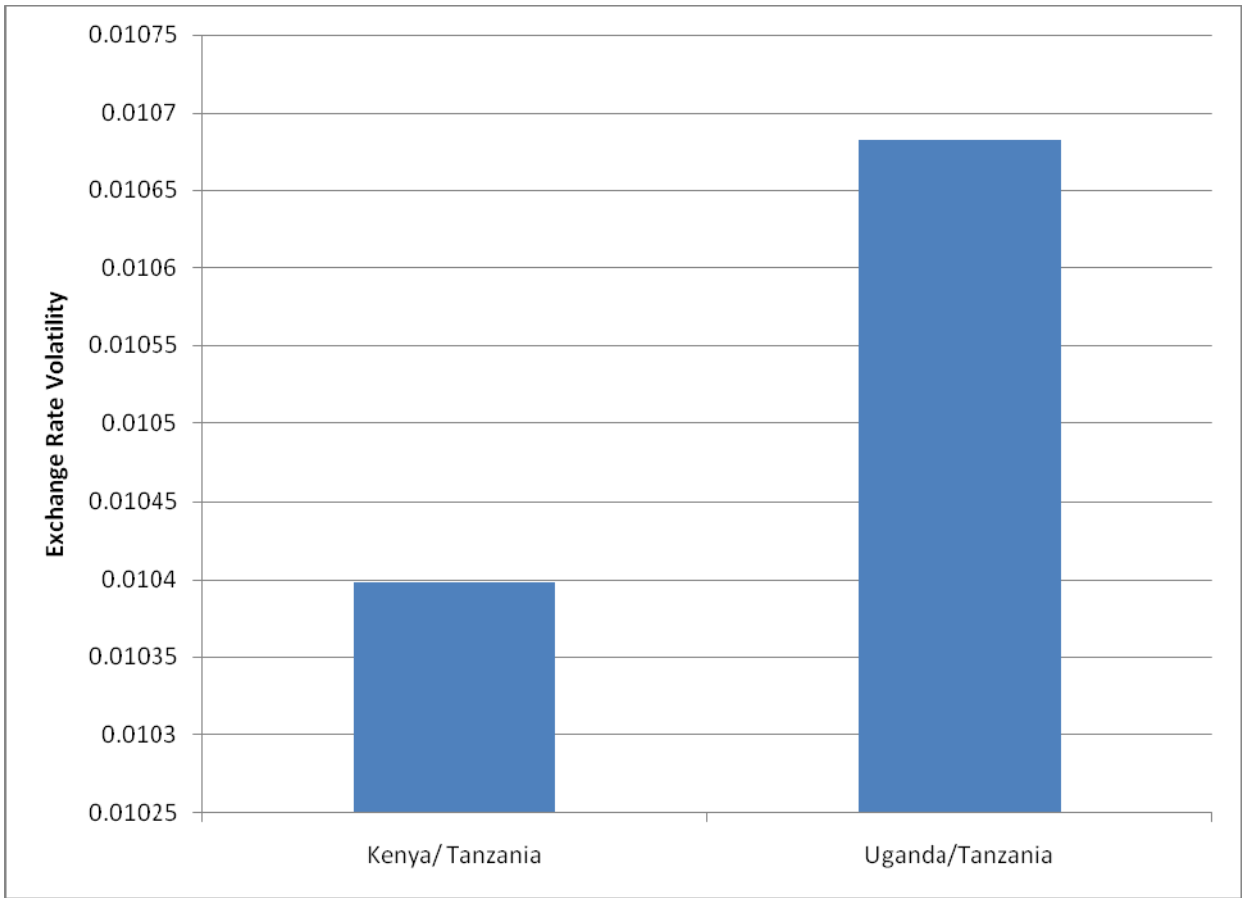

Figure 2.16 The Exchange Rate Volatility - Kenya and Uganda Shillings Versus the Tanzania Shilling, January 2005 - December 2007

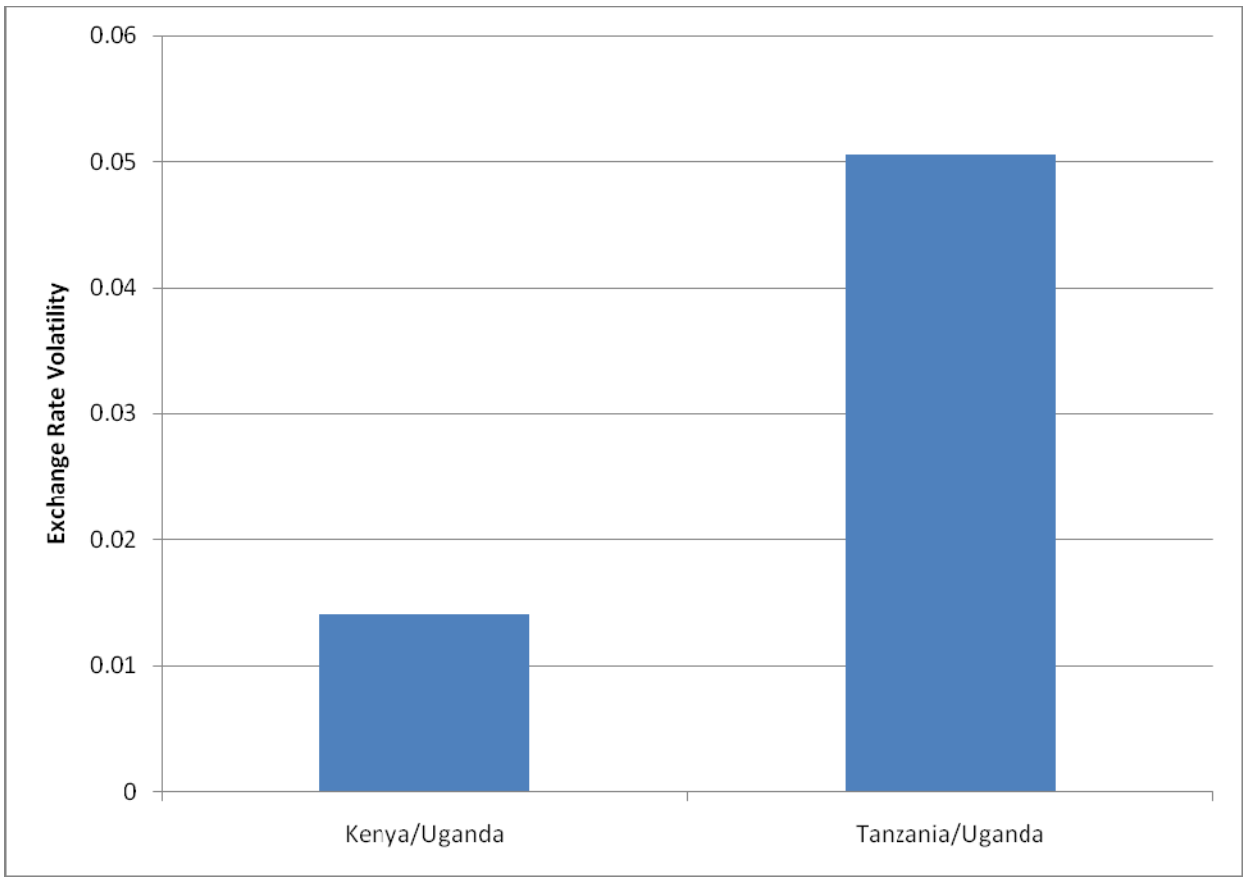

Figure 2.17 The Exchange Rate Volatility - Kenya and Tanzania Shillings Versus the Uganda Shilling, January 2005 - December 2007

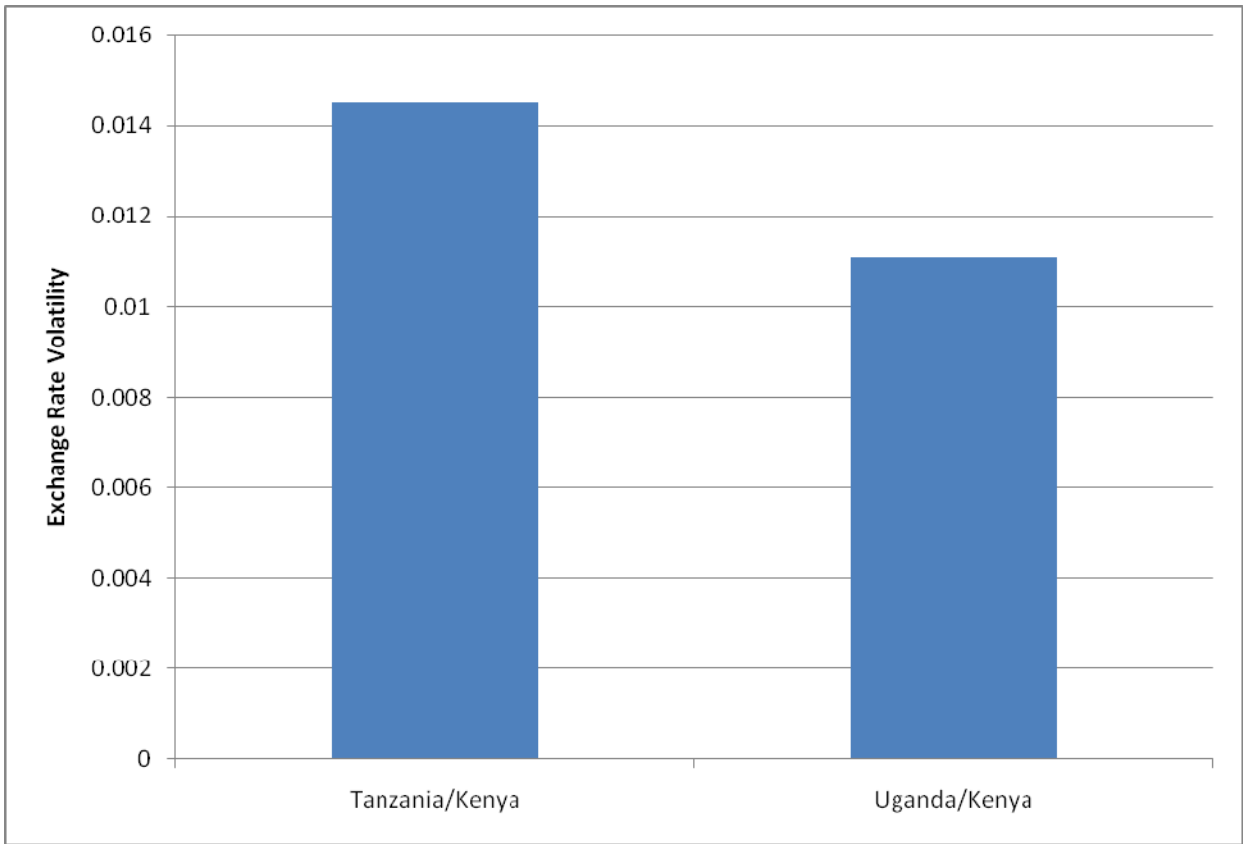

Figure 2.18 The Exchange Rate Volatility - Tanzania and Uganda Shillings Versus the Kenya Shilling, January 2005 - December 2007

The structural similarities in value, stability and volatility of the Kenya Shilling, Tanzania Shilling and Uganda Shilling imply a degree of homogeneity in the monetary policy of the three countries which is consistent with the theory of an optimal currency area. Eichengreen and Bayoumi (1997) examine the link between properties of an optimal currency area and exchange rate volatility and find that countries with more variable exchange rates are subject to larger asymmetric shocks. Optimal currency theory, shows that countries joining a monetary union should have similar shocks and business cycles, high volatility in exchange rates would indicate large asymmetric shocks between the countries.

Agricultural, Food and Maize Production

Agricultural production and food production are important components of the three economies. Agricultural production and food production increased between 1990 and 2006 for the three countries (Fig. 2.19 and Fig. 2.20)[4]. In 1994 agricultural production in Kenya was 91% of the base year production (1999-2001 average), while Tanzania and Uganda where at 84% and 83% respectively, by 2004 agricultural production in Kenya had increased to 113% of the base year production, while Tanzania and Uganda had increased to 106% and 107% respectively. In 1990 food production in Kenya was 87% of the base year production, Tanzania and Uganda where at 89% and 79%, by 2005 food production in Kenya had increased to 116% of the base year production, Tanzania and Uganda had increased to 110% and 106%.

[4] Agricultural production includes both food commodities and non-food commodities, while food production only includes food commodities. Some important non-food commodities in East Africa are coffee, tea and flowers.

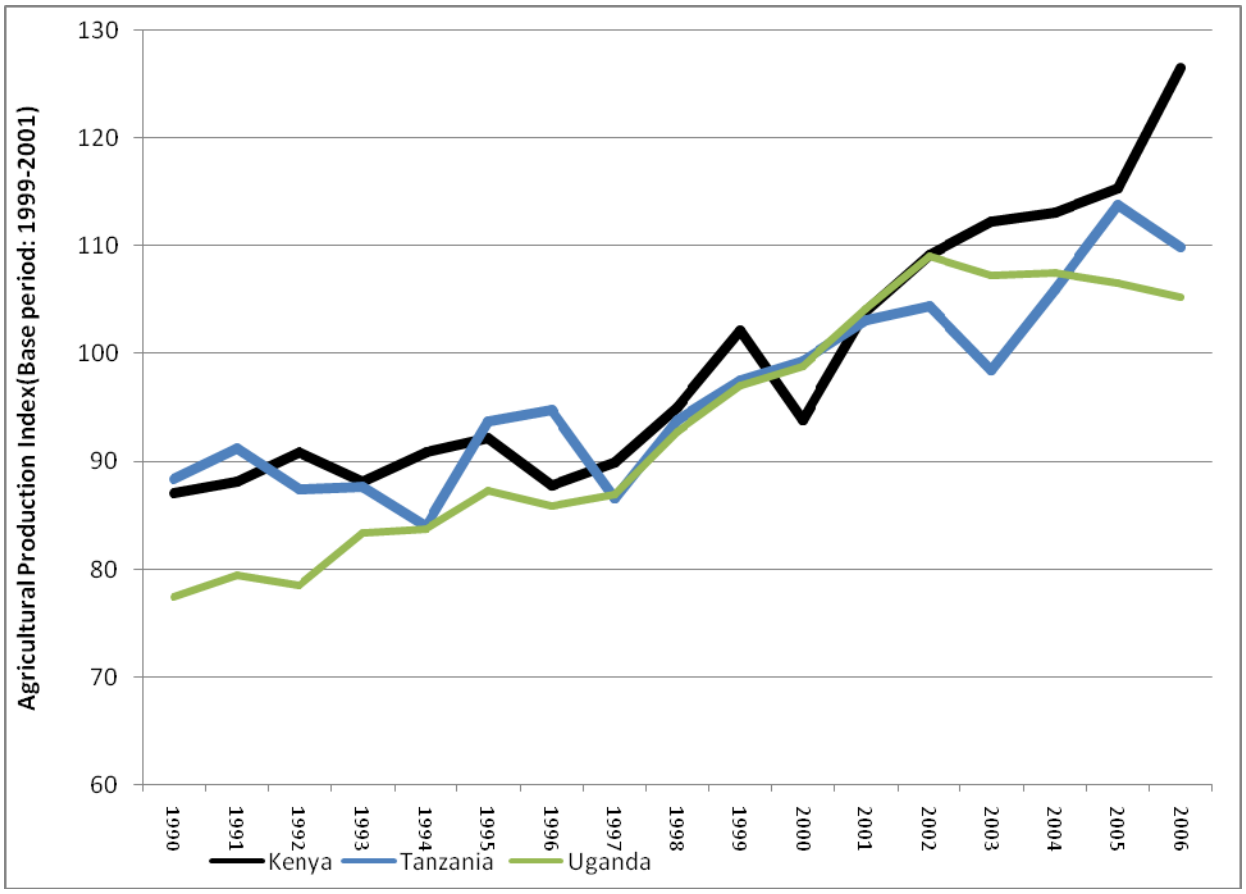

Figure 2.19 Volume of Agricultural Production Index - Kenya,Tanzania and Uganda, 1990 - 2006 (Base period:1999 - 2001).

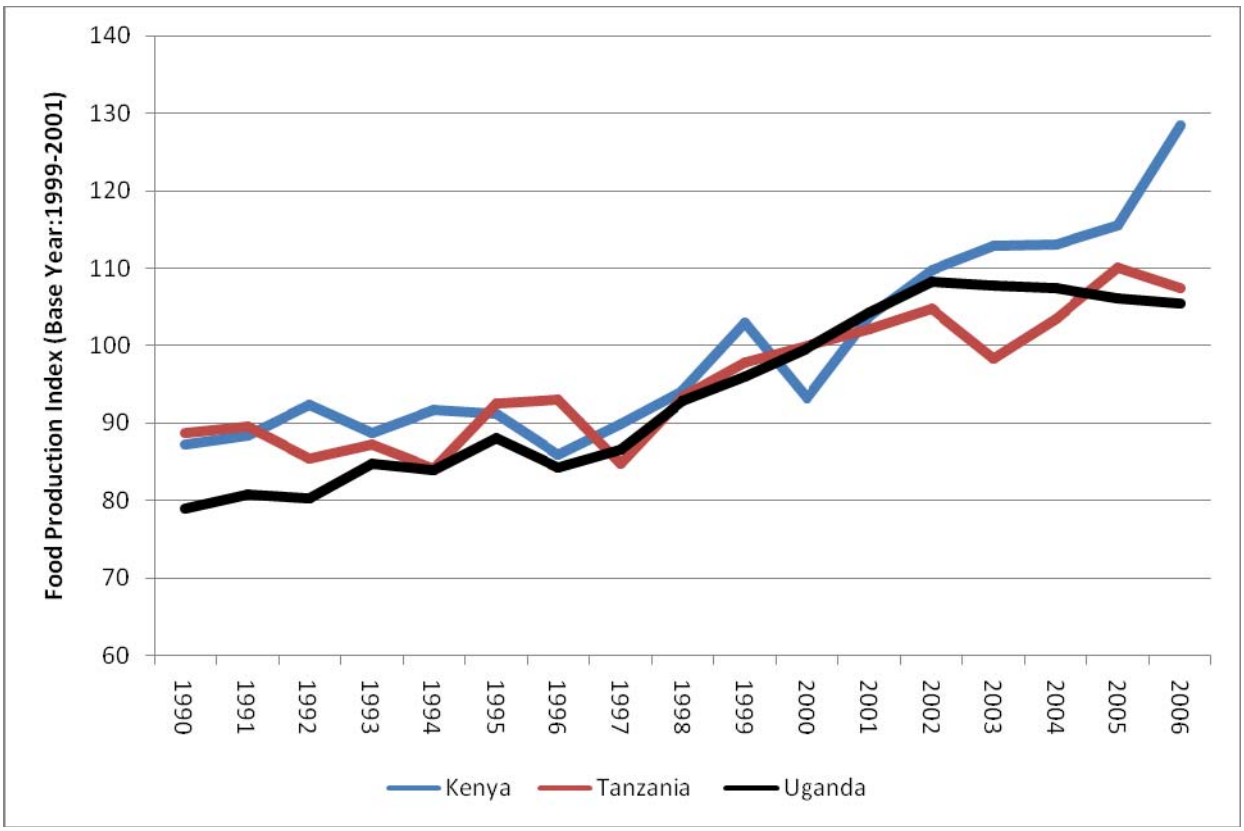

Figure 2.20 Food Production Index - Kenya,Tanzania and Uganda, 1990 - 2006 (Base period:1999-2001).

Important agricultural exports from East Africa include the following; coffee, fish, tea, and tobacco products (Fig. 2.21). Maize constitutes a small share of East African exports to the rest of the world, however in intra-regional East Africa trade, maize constitutes a significant share of agricultural trade, 90% of maize produced is consumed in East Africa (RATIN, 2008) while over 90% of coffee and tea products are exported outside East Africa.

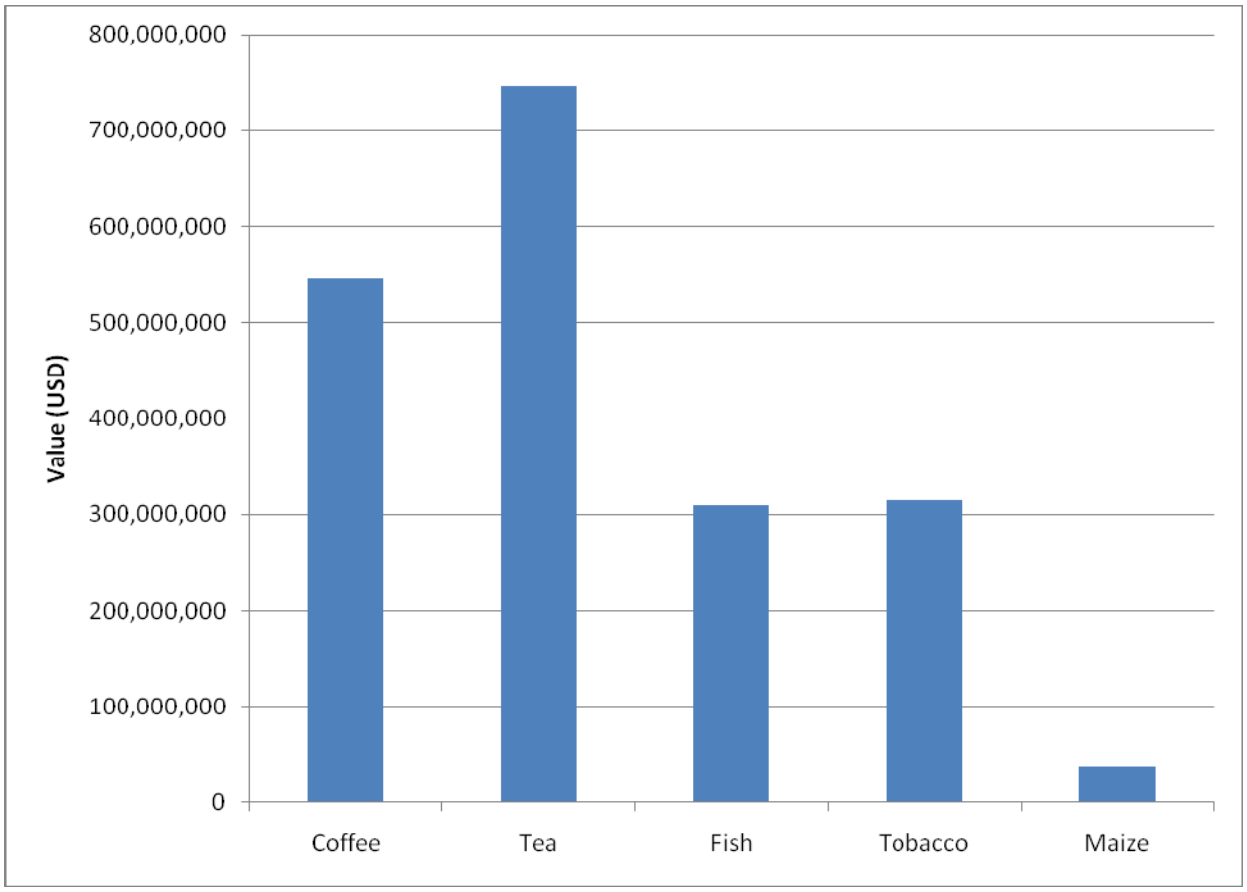

Figure 2.21 World Trade values for major East African Agricultural products

Although single currency will have economy wide regional ramifications, this study focuses on maize, an important food crop in Kenya, Tanzania and Uganda. Maize market responses to the single currency policy will shed some light on possible adjustments in the regional agricultural sector.

The regional total maize production in 2006 amounted to 7,880,206 tons harvested from 4,709,191 hectares averaging 1,737.0 kilograms per hectare. Annual production levels in Kenya and Tanzania were higher but more variable than in Uganda (Fig. 2.22).

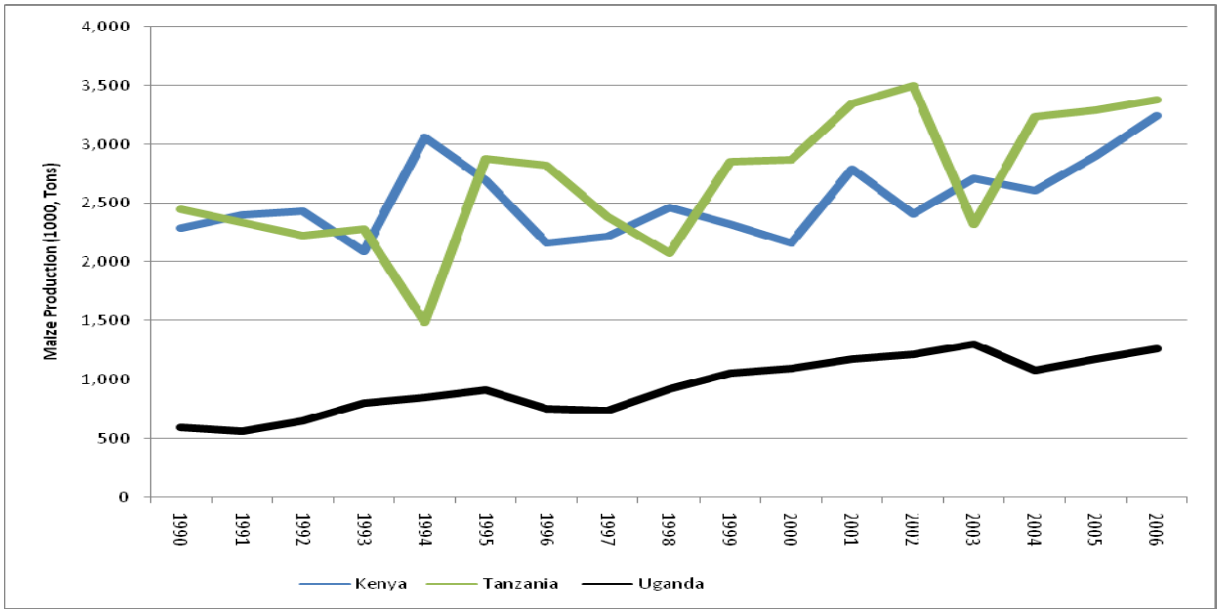

Figure 2.22 Volume of Maize Production – Kenya,Tanzania and Uganda, 1990 – 2006

Mean annual production (1990-2006) was higher in Kenya and Tanzania and more than double that of Uganda (Fig. 2.23).

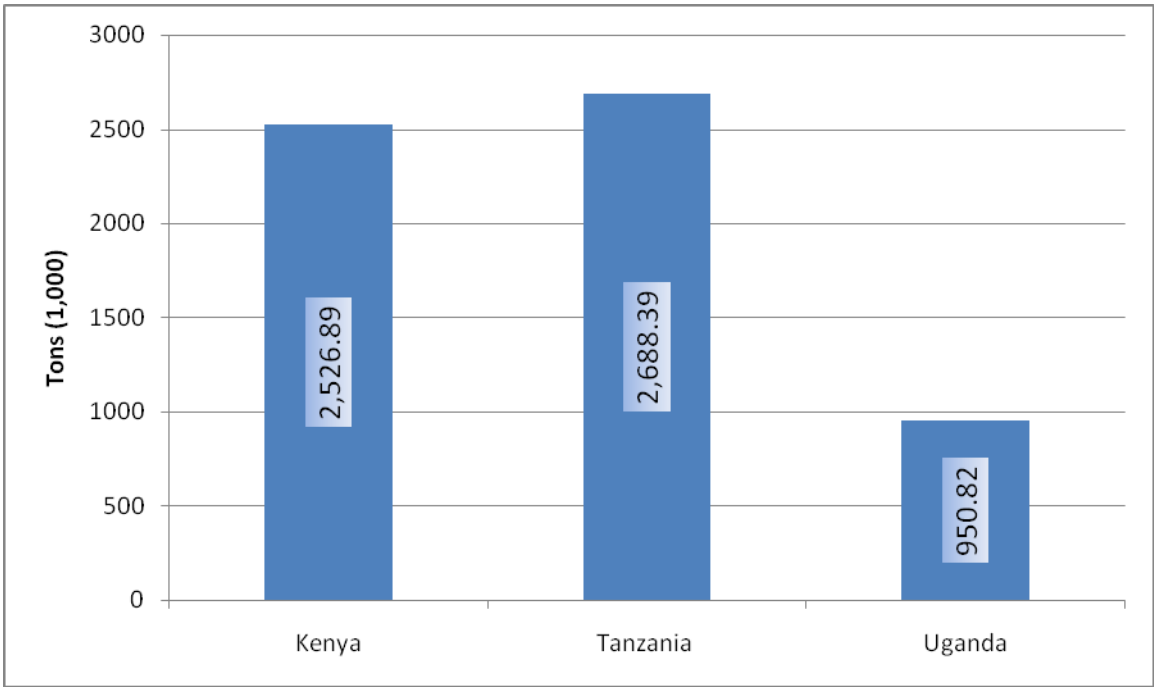

Figure 2.23 Mean Maize Production – Kenya,Tanzania and Uganda, 1990 – 2006

However, maize production more than doubled in Uganda between 1990 and 2006 (Fig. 2.24) while the comparable growth rates in Kenya and Tanzania were 42% and 38%, respectively; and the maize production growth rate was less variable in Uganda than in Kenya and Tanzania (Fig. 2.25).

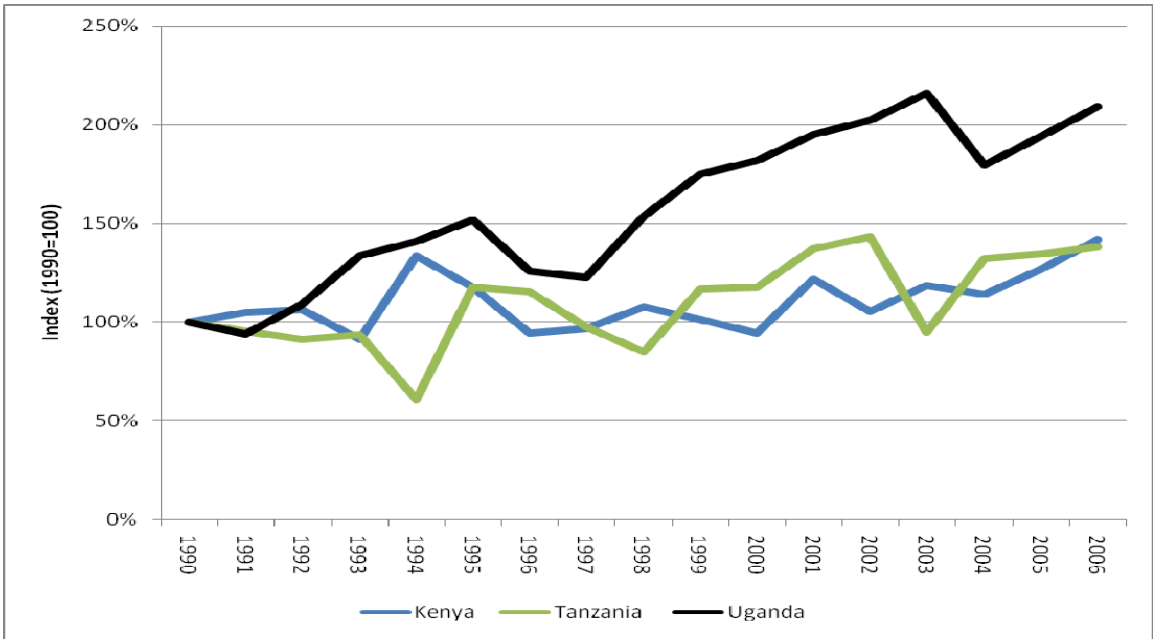

Figure 2.24 Maize Production Index - Kenya,Tanzania and Uganda, 1990 - 2006

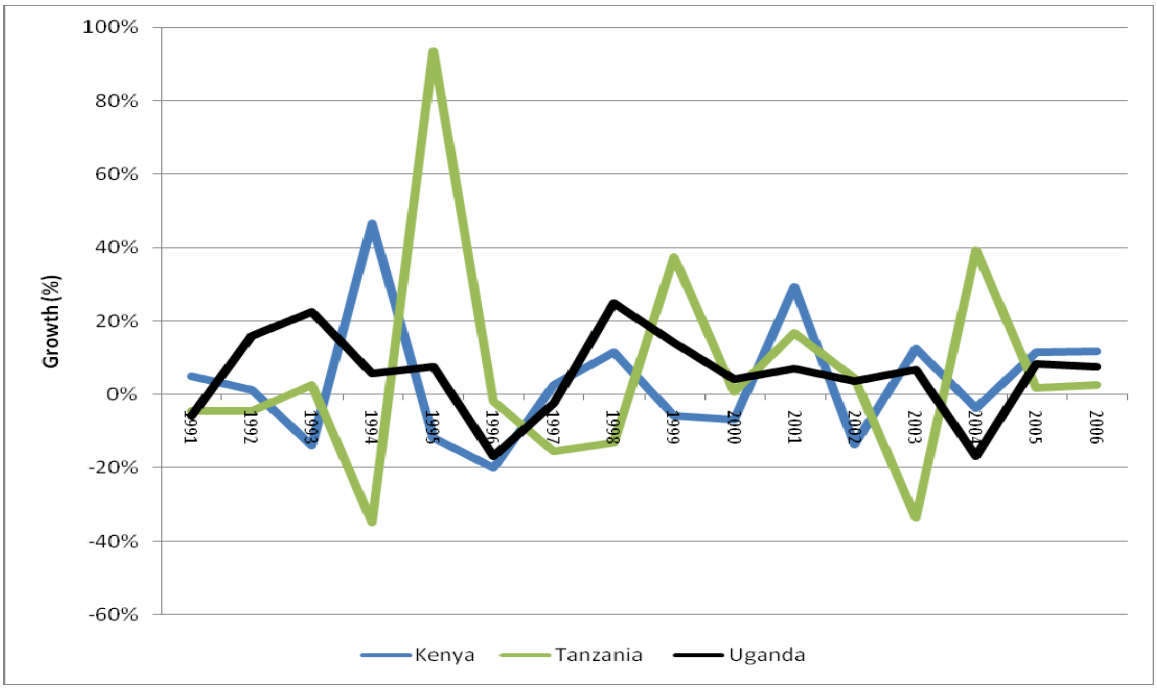

Figure 2.25 Maize Production Growth Rate- Kenya,Tanzania and Uganda, 1990 – 2006

Annual maize export and import volumes were higher and more variable in Kenya and Tanzania than Ugandan (Fig. 2.26 and Fig. 2.27). Kenya imported more than double the combined volume imported by Tanzania and Uganda (Fig. 2.28) while Kenyan and Tanzanian exports in the same period were approximately the same and higher than Ugandan exports(Fig. 2.29).

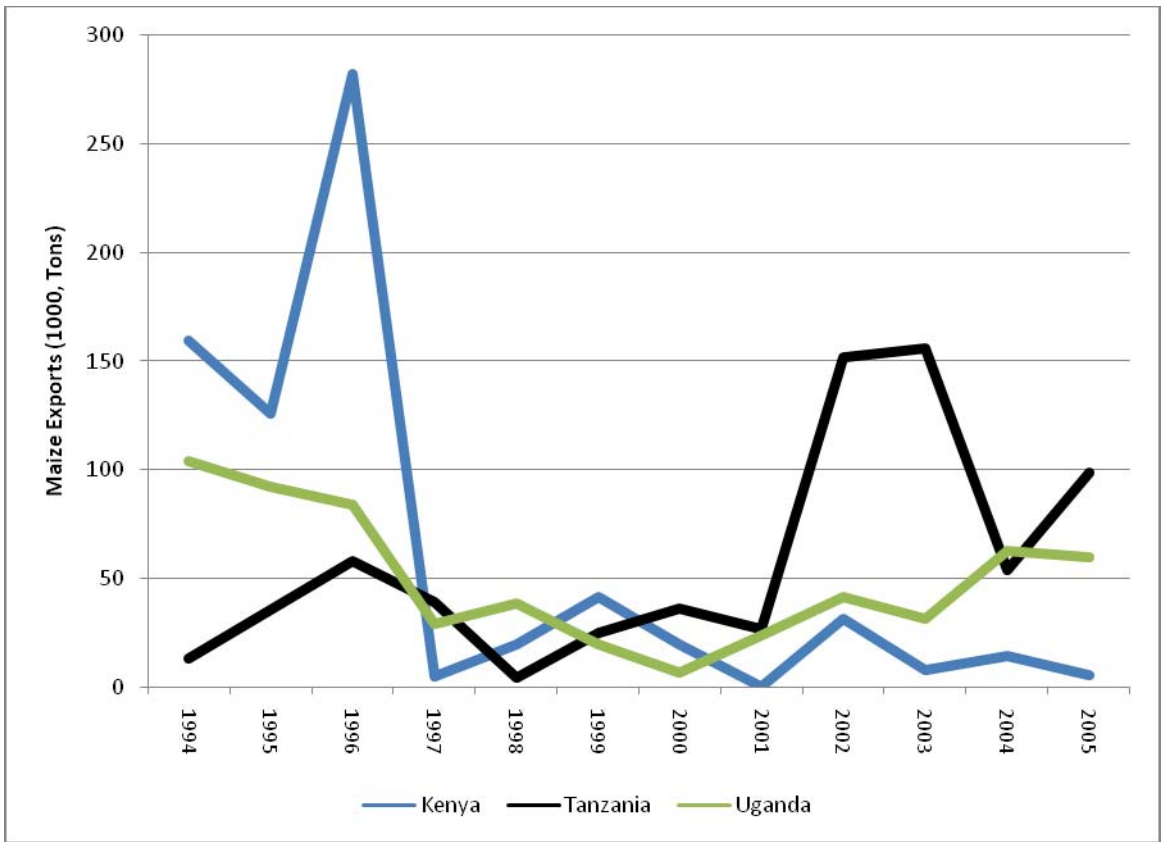

Figure 2.26 Volume of Maize Exports- Kenya,Tanzania and Uganda, 1994 – 2005

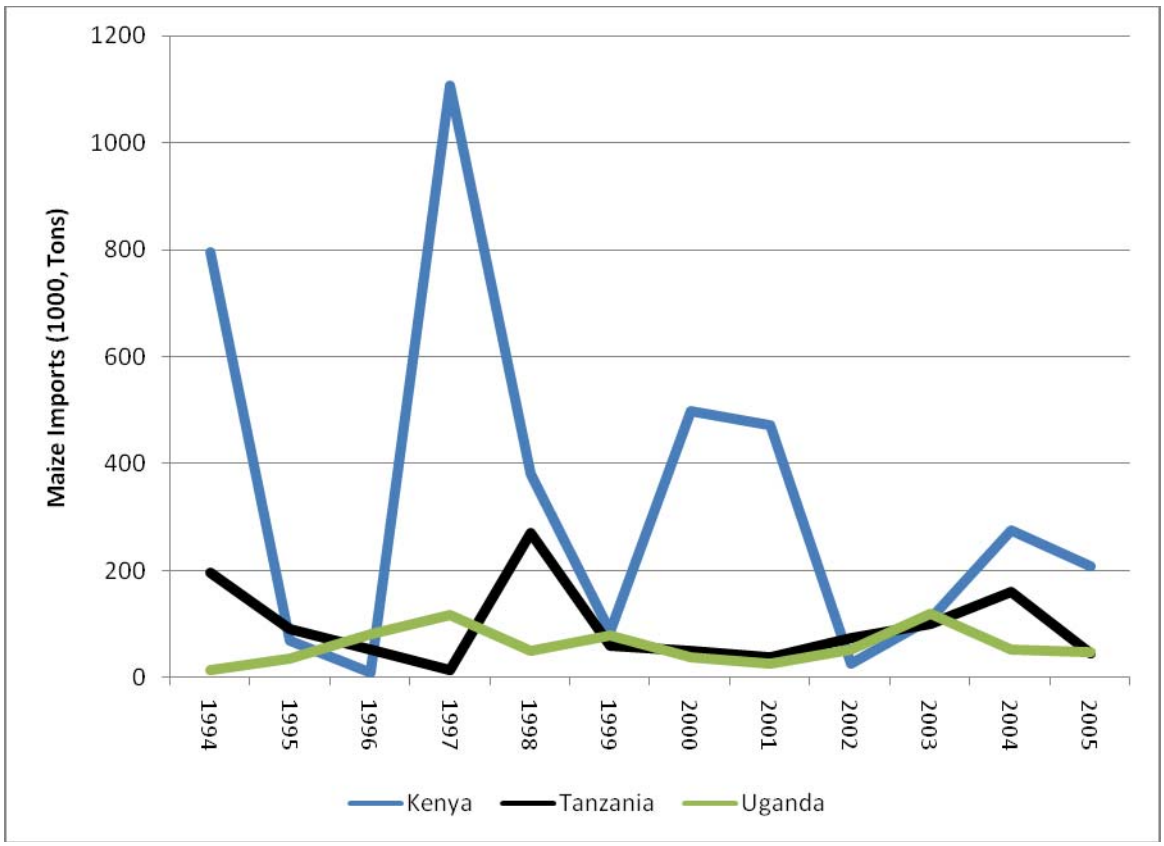

Figure 2.27 Volume of Maize Imports- Kenya,Tanzania and Uganda, 1994 - 2005

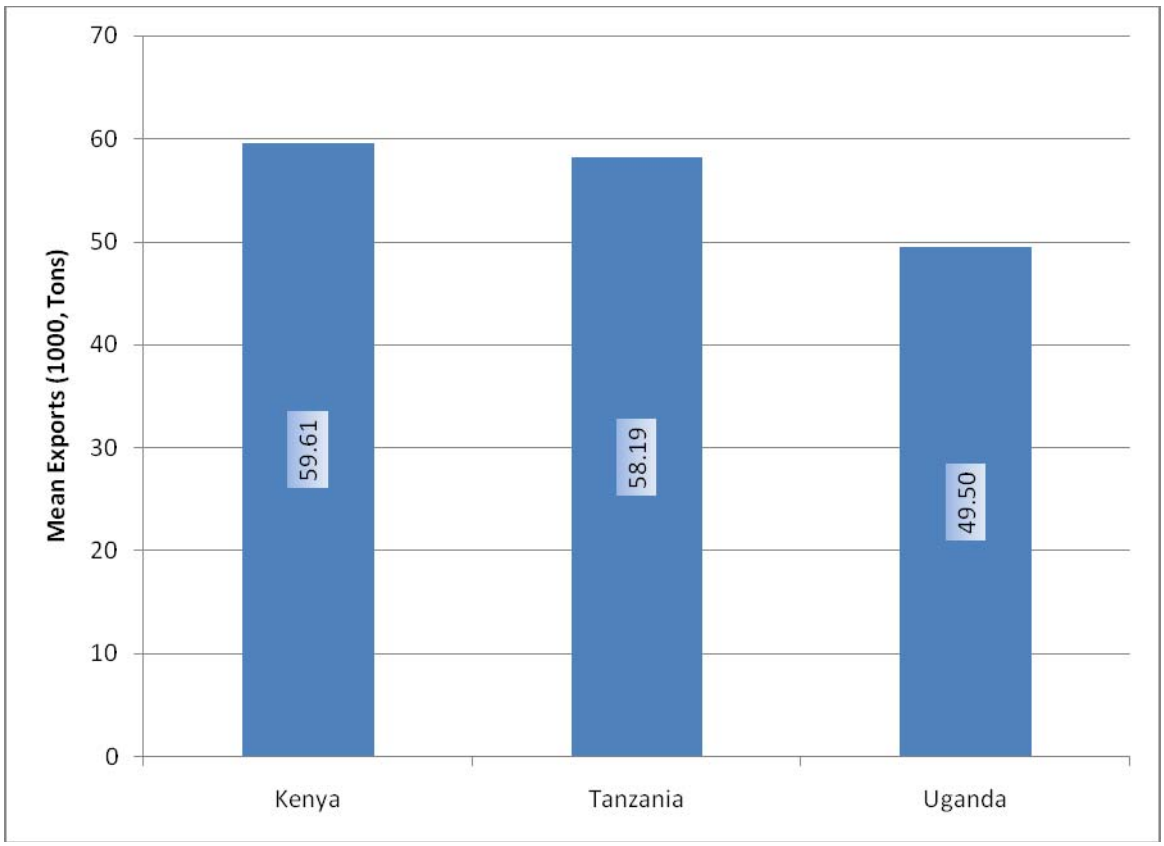

Figure 2.28 Mean Maize Exports – Kenya,Tanzania and Uganda, 1994 – 2005

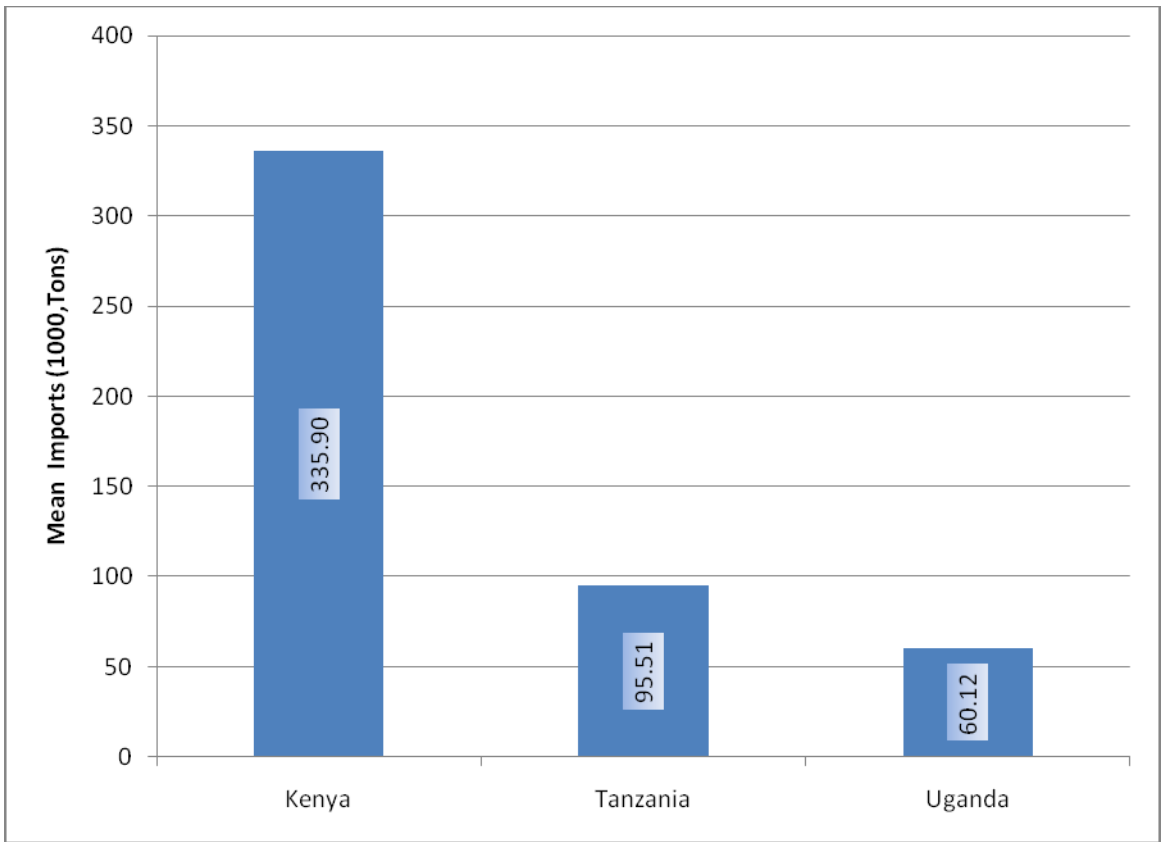

Figure 2.29 Mean Maize Imports – Kenya,Tanzania and Uganda, 1994 – 2005

Maize imports to Uganda increased by over 300% in 2006 compared to the base year period while imports to Kenya and Tanzania decreased to 23% of the base year levels (Fig. 2.30). Maize exports from Kenya and Uganda decreased to 4% and 58% of base year levels in 2006, while Tanzania exports increased to over 700% of base year levels in 2006.

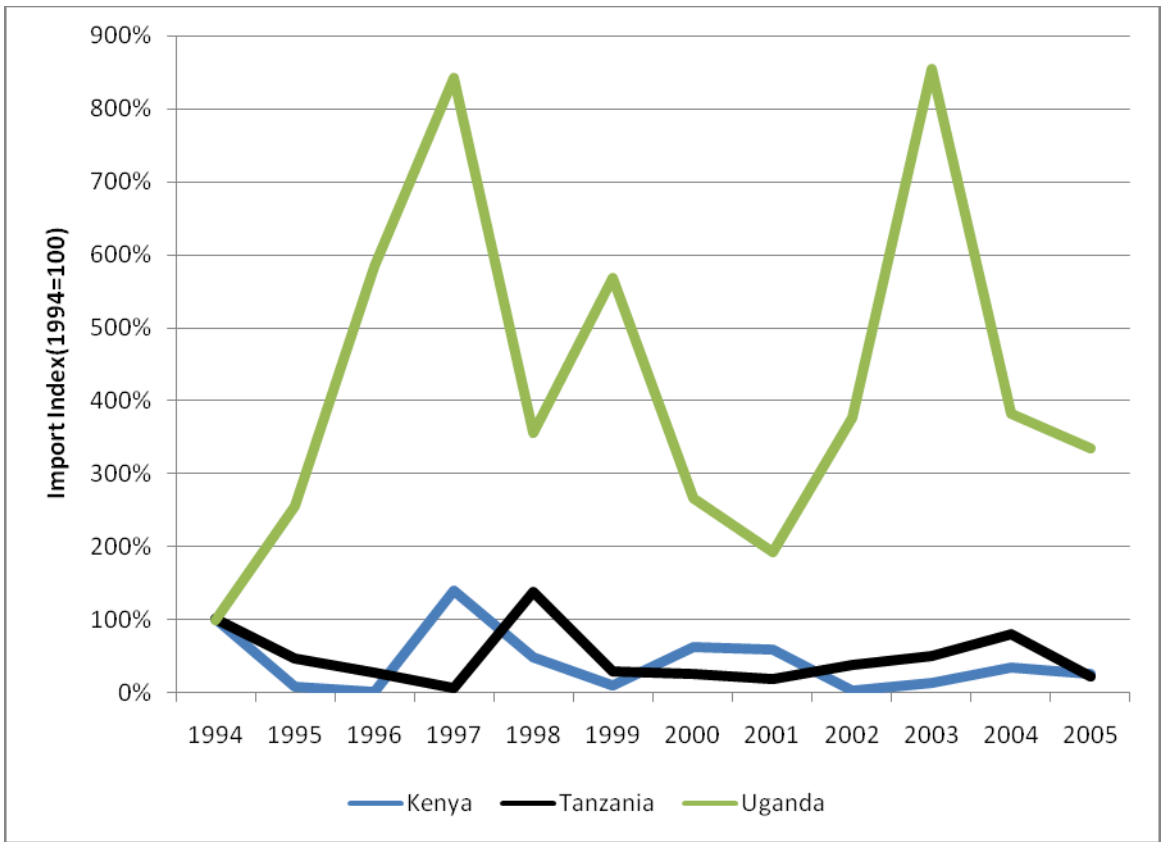

Figure 2.30 Maize Import Index - Kenya, Tanzania and Uganda, 1994 - 2005

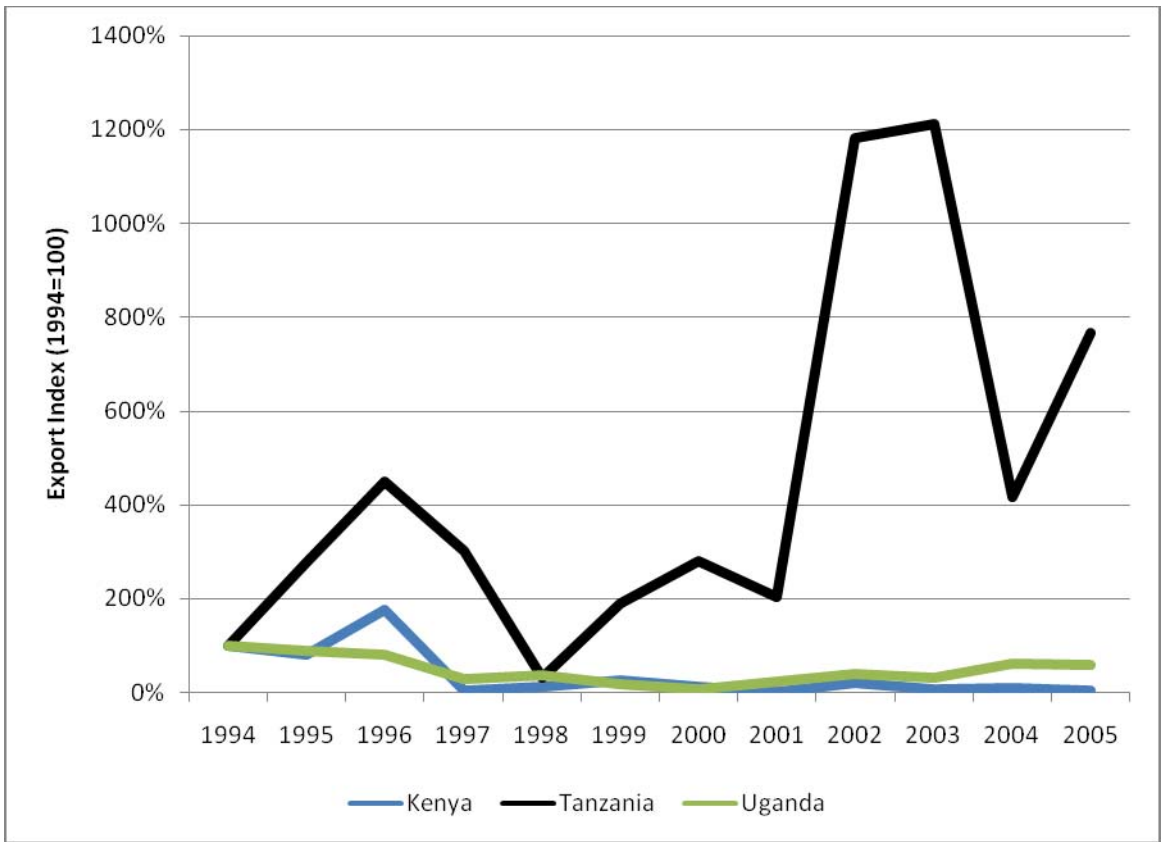

Figure 2.31 Maize Export Index - Kenya, Tanzania and Uganda, 1994 - 2005

Maize prices in Kenya, Tanzania and Uganda increased by 164%, 208% and 222% respectively in May - 2008 compared to base period prices (Fig.2.32) with mean prices highest in Kenya, Tanzania and Uganda respectively (Fig. 2.33). Price variability was highest in Tanzania, Uganda and Kenya respectively (Fig.2.34).

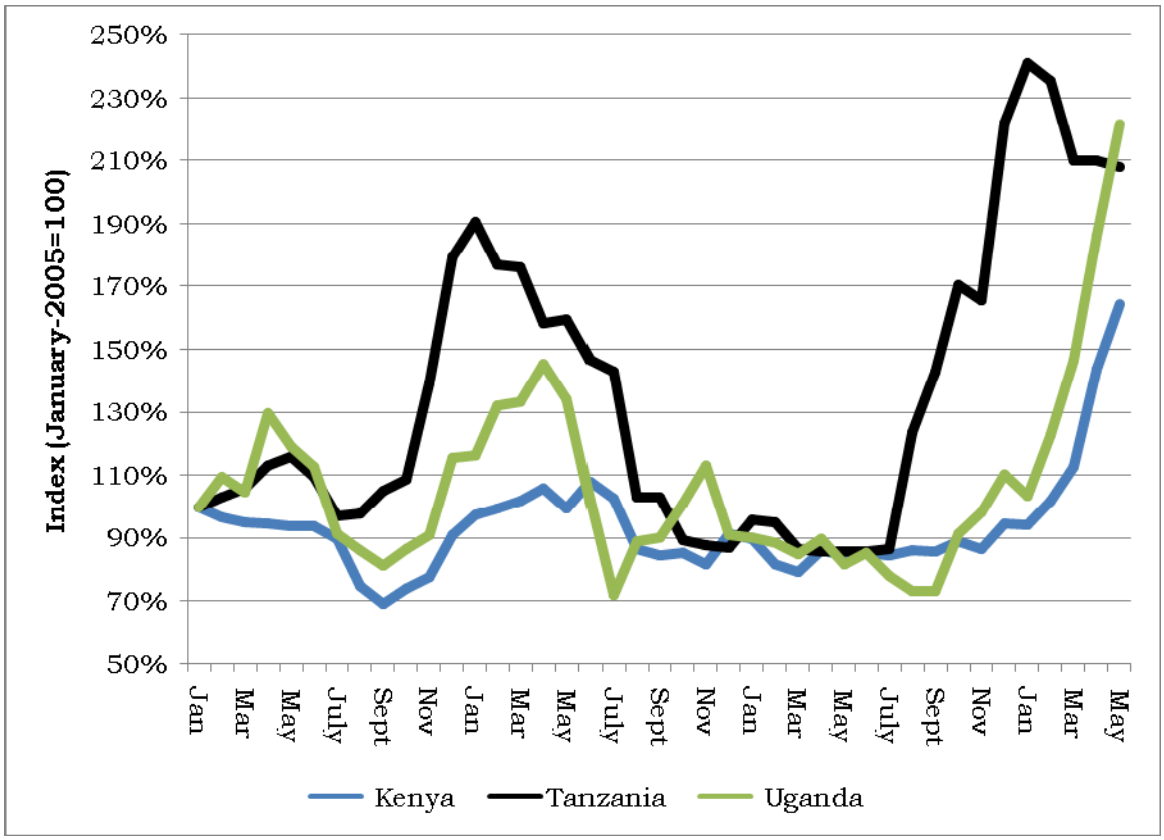

Figure 2.32 Maize Price Index - Kenya, Tanzania and Uganda, January, 2005 - May, 2008

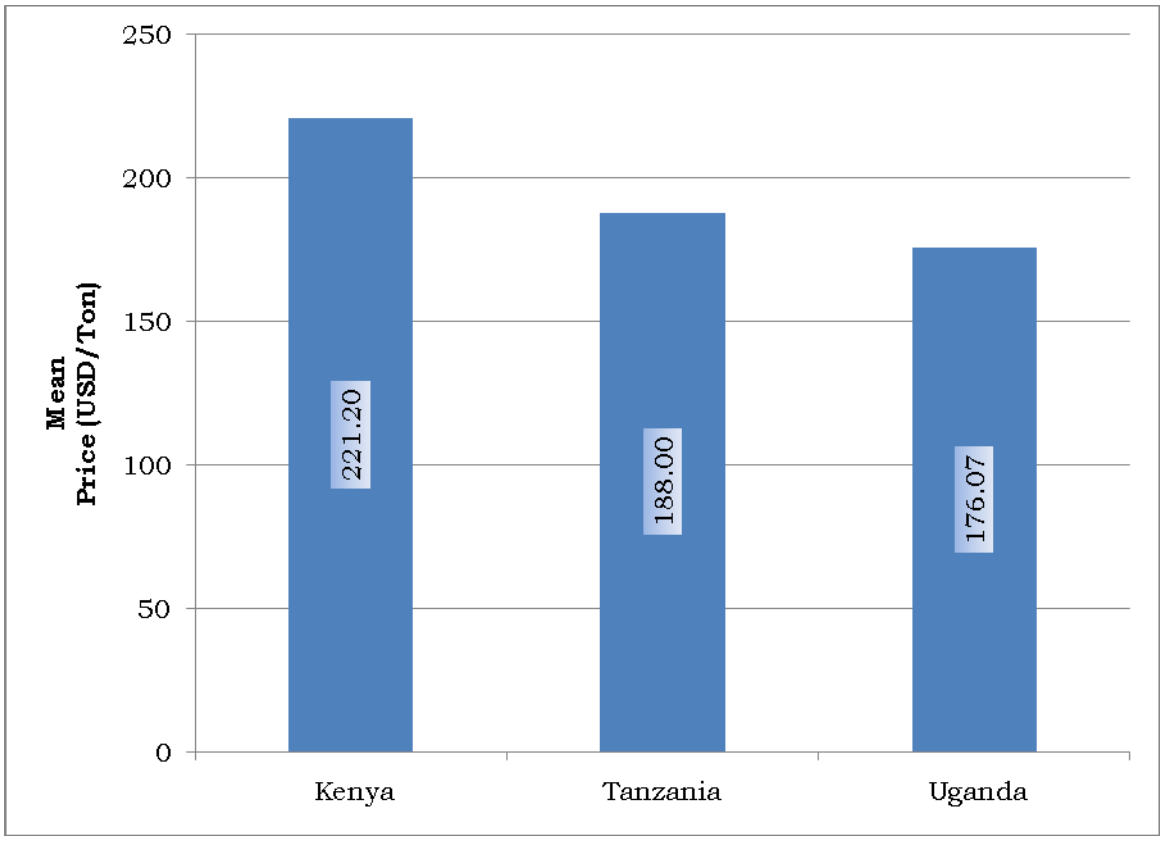

Figure 2.33 Mean Maize Price - Kenya, Tanzania and Uganda, January, 2005 - May, 2008

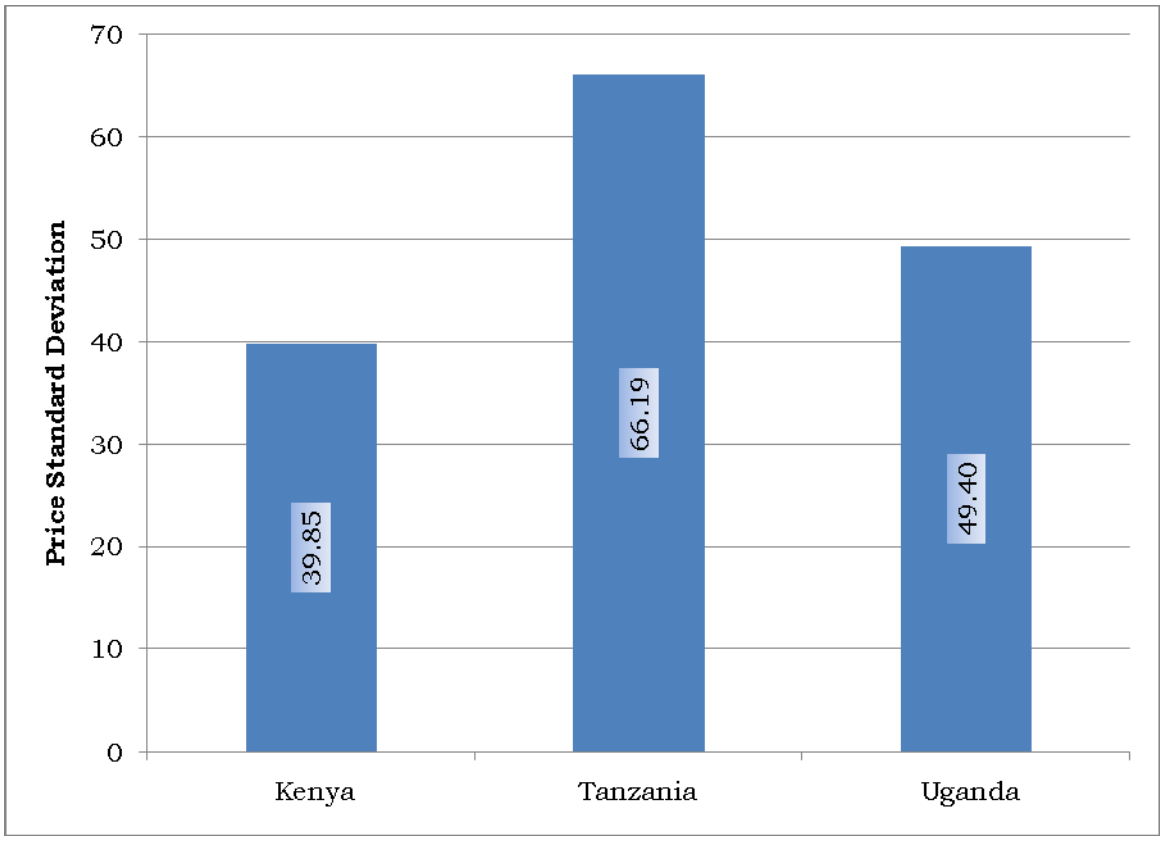

Figure 2.34 Standard Deviation of Maize Prices - Kenya, Tanzania and Uganda, January, 2005 - May, 2008

CHAPTER THREE

LITERATURE REVIEW

According to Mundell (1961), single currency areas should be made up of nations within which prices and wages were flexible and factors of production highly mobile, these nations would constitute an optimal currency area while nations with factor immobility should have separate currencies. Mckinnon (1963), argues for a high degree of economic openness (a high ratio of tradable to non tradable goods) between nations in an optimal currency area. According to Mongelli (2002) other properties of an optimal currency area include: similarity in inflation rates, similarity of shocks and business cycles, fiscal and political integration.

Some empirical studies of optimal currency areas have focused on the extent to which countries meet the theoretical criteria of an optimal currency area. Eichengreen (1991) measured labor mobility and the incidence of shocks in Europe. Beine et al., (2000) assessed the composition of the European optimal currency area based on the degree of asymmetry of real shocks. Mkenda (2001) studied the East African Community, comprising of Kenya, Tanzania, and Uganda, and whether it constituted an optimum currency area. They used a Generalized Purchasing Power Parity method to test for cointegation between the real exchange rates in East Africa. They found that the real exchange rates were cointegrated which indicated a long-run (equilibrium) relationship between the exchange rates due to similar shocks in the region.

Other studies have focused on the after effects of a currency union. Frankel and Rose (1997) argued that countries that trade highly together are more likely to have correlated business cycles, therefore countries in a currency union trading together will end up with synchronized business cycles. However Krugman (1993) argued that a monetary union will lead to greater

regional economic instability because countries in the monetary union tend to specialize in the production of goods in which they enjoy comparative advantages leading to less regional diversification in production and making these regions more susceptible to demand and technology shocks.

Rose (2000) investigated the effects of currency unions on trade and found that bilateral trade tripled for countries in a currency union. Reuven and Rose (2001) found that a currency union increased trade by 100%. Frankel and Rose (2002) found that a currency union tripled trade, while Rose and Wincoop (2001) found that a currency union increased trade by over 50%. Rose (2000) used a panel data set that included bilateral observations for the period 1970 - 1990 for 186 countries, Reuven and Rose (2001), used a data set of 217 countries for the period 1948 - 1997, Rose and Wincoop (2001) used panel data sets of 200 countries for the period 1970 - 1995. The studies by Rose (2000), Reuven and Rose (2001), Rose and Wincoop (2001), Frankel and Rose (2002), used data sets for both developed and developing nations. Other studies used data sets of a homogeneous group of countries. Souza (2002) used a sample of economically developed countries that were members of the euro area for the period 1980 -2001. Bun et al., (2002) used data on annual exports between 15 European countries for the period 1999-2001. Nardis and Vicarelli (2003) used data on exports between 11 European countries for the period 1980-2000. Baldwin et al., (2005) used import data from manufacturing sectors of 18 industrialized countries for the period 1991 – 1992. Flam and Nordström (2003) and Faruqee (2004) used data from industrialized countries to estimate the effect of the currency unions on trade.

Souza (2002) did not find any significant increase in intra-Euro area trade. Bun et al., (2002) found that the euro had significantly increased trade, with an increase of 4% in the first

year and an increase of 40% in the long-run. Nardis and Vicarelli (2003) found a positive trade effect of the euro ranging between 2.6 and 6.3%. Faruqee (2004) found a positive trade effect of about 10%. Baldwin et al., (2005) found a trade increase of 70 - 112%. Flam and Nordström (2003) found that trade between EC countries increased by 15% while trade between EC and non EC countries increased by 8%. Significant euro effects were concentrated to a few sectors, to goods that were differentiated and required relatively much processing. Thom and Walsh (2002) found no significant trade effect of a currency union on trade between Ireland and the United Kingdom. Fielding and Shields (2004) investigated the effects of the West African monetary union on bilateral trade and found evidence of a positive single-currency effect on trade.

In general, the majority of previous studies show that currency unions increase trade with the increase ranging from 300%-0%, therefore one would expect that the trade impact of an East African currency union would be positive based on these results.

CHAPTER FOUR

METHODOLOGY

The single currency literature suggests that there are positive trade and welfare effects of currency union, which arise from various sources and transmitted through the market mechanism. This study specifies and estimates a single-commodity multi-country spatial equilibrium model to evaluate possible trade and welfare effects of the proposed single currency for Kenya, Tanzania and Uganda through reductions in transactions costs of trade arising out of inter-country differences in interest rates, speculation, or intervention by the central banks, when goods are invoiced in the currency of the exporting country.

Following Takayama and Judge (1971), we define price dependent regional market demand and supply functions as

(1) $$y = D(p_i) = \alpha_i - \beta_i p_i, \quad x = S(p^i) = \theta_i - \gamma_i p^i$$

Where, *i*, denotes country (*i = 1, 2, ..., n*) p_i and p^i are the demand and supply prices, respectively, α_i and β_i are the parameters of the demand function, and θ_i and γ_i are the parameters of the supply function.

Excess demand is the difference between the quantity demanded at price p_i and the quantity supplied at price p^i.

(2) $$E(p) = y - x = D(p_i) - D(p^i) = \alpha_i - \beta_i p_i - \theta_i - \gamma_i p^i$$

Suppose the area under (2) is the quasi welfare function defined as follows.

(3) $$W_i = \int_{p_i}^{\rho_i - w_i} d_i(p_i)dp_i - \int_{p^i}^{\rho_i + v_i} s_i(p^i)dp^i$$

(4) $$W_i = \int_{p_i}^{\rho_i - w_i} (\alpha_i - \beta_i p_i)\, dp_i - \int_{p_i}^{\rho_i + v_i} (\theta_i + \gamma_i p^i)\, dp^i$$

(5) $$W_i = K + \alpha_i(\rho_i - w_i) - \frac{1}{2}(\rho_i - w_i)\beta_i(\rho_i - w_i) - \theta_i(\rho^i + v_i) - \frac{1}{2}(\rho^i + v_i)\gamma_i(\rho^i + v_i)$$

p_i and p^i are the pre-trade equilibrium demand and supply prices, Where $p_i = p^i$, $w_i \geq 0, \rho_i \geq 0$. The total welfare function over all countries is defined as

(6) $$\sum_{i=1}^{n} W_i = K + \alpha'(\rho_y - w) - \frac{1}{2}(\rho_y - w)'\beta(\rho_y - w) - \theta'(\rho_x - v) - \frac{1}{2}(\rho_x + v)'\gamma(\rho_x + v)$$

The Lagrangean for the welfare function (6) is defined as

(7) $$\phi(\rho, \xi_X) = \alpha'(\rho_y - w) - \frac{1}{2}(\rho_y - w)'\beta(\rho_y - w) - \theta'(\rho_x + v) - \frac{1}{2}(\rho_x + v)'\gamma(\rho_x + v) + \xi_X'\left(T - G\begin{pmatrix}\rho_y \\ \rho_x\end{pmatrix}\right),$$

Where

$$\xi_X = (\xi_{11}\xi_{12} \ldots\ldots \xi_{1n} \ldots\ldots \xi_{n1}\xi_{n2} \ldots\ldots \xi_{nn})'.$$

The Kuhn-Tucker optimality conditions are:

(8a) $$\frac{\partial \phi}{\partial \rho_i} = \alpha_i - \beta_i(\rho_i - w_i) - \sum_j \xi_{ji} \leq 0 \quad \text{and} \quad \frac{\partial \phi}{\partial \rho_i}\rho_i = 0,$$

(8b) $$\frac{\partial \phi}{\partial \rho^i} = -(\theta_i + \gamma_i(\rho^i + v_i)) + \sum_j \xi_{ij} \leq 0 \text{ and } \frac{\partial \phi}{\partial \rho^i}\rho^i = 0,$$

(8c) $$\frac{\partial \phi}{\partial w_i} = -(\alpha_i - \beta_i(\rho_i - w_i)) \leq 0 \text{ and } \frac{\partial \phi}{\partial w_i} w_i = 0,$$

(8d) $$\frac{\partial \phi}{\partial v_i} = -(\theta_i + \gamma_i(\rho^i + v_i)) \leq 0 \text{ and } \frac{\partial \phi}{\partial v_i} v_i = 0,$$

(8e) $\dfrac{\partial \phi}{\partial \xi_{ij}} = -\rho_j + \rho^i + t_{ij} \geq 0$ and $\dfrac{\partial \phi}{\partial \xi_{ij}} \xi_{ij} = 0.$

By writing

$$y_i = \alpha_i - \beta_i(\rho_i - w_i)$$
$$x_i = \theta_i + \gamma_i(\rho^i + v_i),$$

for all i.

We finally get

(9a) $y_i - \sum_j \xi_{ji} \leq 0$ and $(y_i - \sum_j \xi_{ji})\rho_i = 0$,

(9b) $-x_i + \sum_j \xi_{ij} \leq 0$ and $(-x_i + \sum_j \xi_{ij})\rho^i = 0,$

(9c) $-y_i \leq 0$ or $y_i \geq 0$ and $y_i w_i = 0$

(9d) $-x_i \leq 0$ or $x_i \geq 0$ and $x_i v_i = 0$

(9e) $\rho_j - \rho^i - t_{ij} \leq 0$ and $(\rho_j - \rho^i - t_{ij})\xi_{ij} = 0,$ for all i and j.

The Lagrangean multipliers, ξ_{ij}, are interpreted as the inter-country commodity flows. Equation (9a) describes the optimal consumption condition, it states that when demand price, ρ_i, is positive, the difference between demand in country i and inter-country commodity flows to country i, $y_i - \sum_j \xi_{ji}$, is equal to zero.

Equation (9b) describes the optimal supply condition, it states that when supply price, ρ^i, is positive, the difference between supply in country i and inter-country commodity flows from country i, $-x_i + \sum_j \xi_{ij}$, is equal to zero.

Equation (9e) describes the spatial equilibrium condition, it states that when, ξ_{ij}, is positive, the difference between market demand and supply prices, $\rho_j - \rho^i$, is equal to the unit

transportation cost, t_{ij}, and if, $\xi_{ij} = 0$, the difference between market demand and supply prices, $\rho_j - \rho^i$, is less than or equal to the transportation cost.

The transaction cost, ϕ_{ij}, between countries i and j is treated as exogenous, it is represented as a fraction of transport costs ($0 < \phi$).

The spatial equilibrium condition (9e) can be written as

(10) $\rho_j - \rho^i - t_{ij}(1+\phi_{ij}) \leq 0$ and $(\rho_j - \rho^i - t_{ij}(1+\phi_{ij}))\xi_{ij} = 0$.

East Africa Model

We use an intra-regional trade model to explore the impact of the currency union using a GAMS framework. The details are given in the appendix A**.** The model consists of a set of supply and demand functions for Kenya, Uganda and Tanzania, a trade flow matrix and the spatial price equilibrium conditions. It measures the response of the intra-regional maize market to a change from multiple national currencies to single currency. The model is solved using the non linear programming.

Data

Maize consumption, supply and price data for Kenya, Tanzania and Uganda were obtained from the Regional Agricultural Trade Intelligence Network (RATIN). The monetary value is the United States dollar, the quantities are in metric tons. Data on the regional transport costs of maize were obtained from RATIN . Maize supply and demand elasticties for Kenya were obtained from Karanja (2002), supply and demand elasticities for Tanzania were obtained from Cutts and Hassan (2003). Supply and demand elasticities for Uganda were obtained from Sserunkuuma (2004).

CHAPTER FIVE

RESULTS AND CONCLUSION

Results

The GAMS solutions of the East African Single Currency Model are reported in tables 5.1 – 5.4. Table 5.1 shows the optimal maize production, trade, consumption and prices in the regional economy consisting of Kenya, Tanzania and Uganda for national and single currency scenarios. Maize production, trade and average price levels are higher in the single currency than national currencies scenario, and the intra-regional prices are more convergent.

Maize production quantity is 0.11% higher in the single currency scenario than in the national currencies scenario and the volume of trade as well as the mean regional price of maize are 8.54% and 1.73%, higher in the single currency than national currencies scenario, respectively.

Production and trade values are 1.84% and 10.42% higher in the single currency than the national currencies scenario while intra-regional maize price dispersion is 16.67% lower in the single than national currencies scenario.

Table 5.1 Optimal Maize Production, Trade, Consumption and Prices: East African National and Single Currency Scenarios

Activities and Prices	Currency Scenarios		Difference (%)
	National Currencies	Single Currency	
Production (1,000 Tons)	6,627	6,634	0.11
Regional Trade (1,000 Tons)	147	161	8.54
Production ($M)	786	801	1.84
Regional Trade ($M)	18	19	10.42
Average Price ($/Ton)	119	121	1.73
Regional Price Range ($)	50	41.0	-16.67

Country level production in Table 5.2 is characterized by higher maize production in Uganda but correspondingly lower production in Kenya and Tanzania in the single currency scenario. Maize production is 2.57% higher in Uganda but lower in Kenya and Tanzania by 0.16% and 0.07% respectively, in the single currency scenario. However, domestic supply[5] is higher in Tanzania by 0.06% but lower in Kenya by 0.16% and Uganda by 0.54% in the single currency scenario than in the national currencies scenario.

Furthermore, the volume of Tanzanian exports (Tanzania to Kenya) is 24.7% lower but the volume of Ugandan exports (Uganda to Kenya) is 12.38% higher in the single than national currencies scenario. And maize consumption level is higher by 0.25% in Kenya and 0.06% in Tanzania but lower by 0.54% in Uganda in the single currency scenario than the national currencies scenario.

[5] Quantity produced and consumed domestically.

Table 5.2 Quantity of Maize Production, Consumption and Trade: East African National and Single Currency Scenarios

Activities and Countries	Currency Scenarios		Difference (%)
	National Currencies	Single Currency	
Production (1,000 Tons)			
Kenya	3,001	2,996	-0.16
Tanzania	3,075	3,073	-0.07
Uganda	551	565	2.57
Domestic Supply (1,000 Tons)			
Kenya	3,001	2,996	-0.16
Tanzania	3,060	3,062	0.06
Uganda	418	416	-0.54
Exports (1,000 Tons)			
Tanzania to Kenya	15	11	-24.78
Uganda to Kenya	133	149	12.38
Demand (1,000 Tons)			
Kenya	3,149	3,157	0.25
Tanzania	3,060	3,062	0.06
Uganda	418	416	-0.54

Table 5.3 shows the value of maize production, consumption and trade. The value of maize production is lower in Kenya and Tanzania by 0.64% and 0.65% respectively, but higher in Uganda by 10.44% in the single currency scenario than in the national currencies scenario. The value of maize exports from Tanzania is 25.4% lower while the value of exports from Uganda is 11.85% higher in the single than national currencies scenario.

Table 5.3 Value of Maize Production, Consumption and Trade: East African National and Single Currency Scenarios

Activities and Countries	Currency Scenarios		Difference (%)
	National Currencies	Single Currency	
	----------($ 1,000)----------		
Production			
Kenya	441,208	438,393	-0.64
Tanzania	341,314	339,091	-0.65
Uganda	53,865	59,487	10.44
Domestic Supply			
Kenya	441,208	438,393	-0.64
Tanzania	450,000	338,000	-24.92
Uganda	41,000	44,000	7.08
Exports			
Tanzania to Kenya	2,245	1,681	-25.14
Uganda to Kenya	19,498	21,807	11.85

Table 5.4 shows optimal maize prices and regional net welfare in national and single currency scenarios. Prices in the single currency scenario are lower in Kenya and Tanzania but higher in Uganda. Prices in Kenya and Tanzania are lower by 0.48% and 0.59% respectively, while prices in Uganda are higher by 7.67%. Regional net welfare is higher by 0.03% in the single currency scenario.

Table 5.4 Optimal Maize Prices and Regional Net Welfare in National and Single Currency Scenarios

Countries and Region	Currency Scenarios		Difference (%)
	National Currencies	Single Currency	
	----------($)----------		
Kenya	147.03	146.33	-0.48
Tanzania	110.98	110.33	-0.59
Uganda	97.83	105.33	7.67
Region* (RNW)	4,704,200	4,705,400	0.03

Conclusion

Simulation results from the East African Single Currency Model show higher maize production and trade as well as changes in prices across the region in the single currency scenario. The results suggest that total regional maize production will be higher in the single currency scenario with Uganda having a higher share of regional maize production, while both Kenya and Tanzania will have lower shares of the regional shares of maize production. Producer surplus will be higher in Uganda and lower in Kenya and Tanzania. The spatial redistribution of maize production is attributable to improved regional pricing efficiency.

The single currency scenario will change the intra-regional demand and supply of maize due to a more efficient spatial pricing leading to changes in both the volume of trade and the direction of trade. The demand for maize in Uganda will be lower while the quantity of maize produced in Uganda and exported to Kenya will be higher due to the higher export prices in Kenya; the demand for maize will be higher in Kenya while quantity of maize produced in Kenya will be lower because of the lower import prices from Uganda; Tanzania exports to Kenya will be lower because of the increased competition from the lower prices of Ugandan

Notes:* RNW is Regional net welfare in $1,000

maize exports to Kenya while the demand for maize in Tanzania will be higher because of lower domestic prices. Consumer surplus will be lower in Uganda and higher in Kenya and Tanzania.

The change in the regional maize price structure reflects the effect of foreign exchange transaction costs on commodity markets in the national currencies scenario. The elimination of transaction costs in a single currency scenario is similar to a tariff reduction on maize exports and imports. And with the free flow of goods within the region there are intra-regional realignments of demand and supply functions resulting in new spatial price equilibriums for maize in each country consistently with a more efficient spatial pricing. This is reflected in the narrower spatial price dispersion with higher price in Uganda and lower prices in Kenya and Tanzania under the single currency scenario.

The elimination of transaction costs in a single currency will lead to market adjustments in all the sectors of the regional economy. Demand and supply functions will change resulting in new spatial price equilibriums in the region and more efficient spatial pricing. The mean regional prices will be lower and aggregate regional trade will be higher as result of increased regional specialization due to increased regional integration. Change in revenue will depend on the own-price and cross-price elasticities of demand and supply in the single currency scenario.

Our results suggest a net welfare gain due to a single currency; however the distribution of these gains will not be uniform across the region. Maize producers in Kenya and Tanzania will be worse off, maize consumers in Uganda will also be worse off. It is possible that some producers will exit the maize market and invest their productive resources in other activities with higher returns and that some consumers will substitute from maize to cheaper products depending on own and cross price elasticities. However the extent of the aggregate welfare

change on the East African economy due to a single currency and the distribution effects cannot be determined by the single commodity model used in this paper.

The policy implication of this study is a regional policy reformulation towards a higher degree of monetary and fiscal policy convergence in the region, starting with trade policy harmonization and successively towards a single currency.

Recommended Areas for Future Studies

The study investigates the effects of a single currency on a single commodity; however this study could be extended using a multi-commodity model to determine the effect of a single currency on all the sectors of the regional economy.

The model could be extended to account for risk aversion; in this study we estimate a risk free empirical model.

The study could be extended to include temporal market price relations. Production and consumption of maize are usually separated by time, with storage resources used to bridge the time lag. This study was limited by missing information on storage costs.

APPENDICES

APPENDIX A

Notation Used In the GAMS Model:

Country:		KEN	Kenya
		TAN	Tanzanian
		UG	Uganda
Prices:	PD		Demand price
		PS	Supply price
Quantity:		D	Demand quantity
		S	Supply quantity
Transaction cost:		TRC	Transaction cost
Transport cost:		TC	Unit transportation cost

Demand price (PD):

PDKEN	Demand price in Kenya
PDTZ	Demand price in Tanzania
PDUG	Demand price in Uganda

Supply price (PS):

PSKEN	Supply price in Kenya
PSTZ	Supply price in Tanzania
PSUG	Supply price in Uganda

Demand quantity (D):

DKEN	Demand quantity in Kenya
DTZ	Demand quantity in Tanzania
DUG	Demand quantity in Uganda

Supply quantity (S):

SKEN	Supply quantity in Kenya
STZ	Supply quantity in Tanzania
SUG	Supply quantity in Uganda

Transaction cost (TRC):

TRCKENTZ	Kenya - Tanzania Transaction cost
TRCKENUG	Kenya - Uganda Transaction cost
TRCTZKEN	Tanzania - Tanzania Transaction cost
TRCTZUG	Tanzania - Uganda Transaction cost
TRCUGKEN	Uganda - Tanzania Transaction cost
TRCUGTZ	Uganda- Uganda Transaction cost

Trade:

SKENUG	Kenya to Uganda
SKENTZ	Kenya to Tanzania

STZKEN	Tanzania to Kenya
STZUG	Tanzania to Uganda
SUGKEN	Uganda to Kenya
SUGTZ	Uganda to Tanzania

Domestic supply:

SKENKEN	Domestic supply - Kenya
STZTZ	Domestic supply - Tanzania
SUGUG	Domestic supply - Uganda

Transportation cost (TC):

TCKENTZ	Unit transportation cost - Kenya to Tanzania
TCKENUG	Unit transportation cost - Kenya to Uganda
TCTZKEN	Unit transportation cost - Tanzania to Kenya
TCTZUG	Unit transportation cost - Tanzania to Uganda
TCUGKEN	Unit transportation cost - Uganda to Kenya
TCUGTZ	Unit transportation cost - Uganda to Tanzania

E ≡ Equal

L ≡ Less than

Z ≡ Objective function

APPENDIX B

Specification of the GAMS Model of East African Monetary Union

	VARIABLES	
1	Z	VARIABLE Z ;
2	POSITIVE	VARIABLES
3	SKEN	VARIABLE SKEN
4	SUG	VARIABLE SUG
5	STZ	VARIABLE STZ
6	DKEN	VARIABLE DKEN
7	DUG	VARIABLE DUG
8	DTZ	VARIABLE DTZ
9	SKENKEN	VARIABLE SKENKEN
10	SKENUG	VARIABLE SKENUG
11	SKENTZ	VARIABLE SKENTZ
12	SUGKEN	VARIABLE SUGKEN
13	SUGUG	VARIABLE SUGUG
14	SUGTZ	VARIABLE SUGTZ
15	STZKEN	VARIABLE STZKEN
16	STZUG	VARIABLE STZUG
17	STZTZ	VARIABLE STZTZ
19	PDKEN	VARIABLE PDKEN
20	PDUG	VARIABLE PDUG
21	PDTZ	VARIABLE PDTZ
22	PSKEN	VARIABLE PSKEN
23	PSUG	VARIABLE PSUG
24	PSTZ	VARIABLE PSTZ
25	TRCKENUG	VARIABLE TRCKENUG
26	TRCKENTZ	VARIABLE TRCKENTZ
27	TRCUGTZ	VARIABLE TRCUGTZ
28	TRCTZKEN	VARIABLE TRCTZKEN
29	TRCTZUG	VARIABLE TRCTZUG
30	TRCUGKEN	VARIABLE TRCUGKEN;

	EQUATIONS	
1	EQUATION1	EQUATION1
2	EQUATION2	EQUATION2
3	EQUATION3	EQUATION3
4	EQUATION4	EQUATION4
5	EQUATION5	EQUATION5

6	EQUATION6	EQUATION6
7	EQUATION7	EQUATION7
8	EQUATION8	EQUATION8
9	EQUATION9	EQUATION9
10	EQUATION10	EQUATION10
11	EQUATION11	EQUATION11
12	EQUATION12	EQUATION12
13	EQUATION13	EQUATION13
14	EQUATION14	EQUATION14
15	EQUATION15	EQUATION15
16	EQUATION16	EQUATION16
17	EQUATION17	EQUATION17
18	EQUATION18	EQUATION18
19	EQUATION19	EQUATION19
20	EQUATION20	EQUATION20
21	EQUATION21	EQUATION21
22	EQUATION22	EQUATION22
23	EQUATION23	EQUATION23
24	EQUATION24	EQUATION24
25	EQUATION25	EQUATION25
26	EQUATION26	EQUATION26
27	EQUATION27	EQUATION27
28	EQUATION28	EQUATION28

EQUATION1..Z=E=431.36 *DKEN-0.00004515*DKEN**2+281.03104*SKEN-
0.0000713*SKEN**2+1482.8 *DUG-0.001656712*DUG**2+193.9772*SUG-
0.000264989*SUG**2+1213.2 *DTZ-0.000180094*DTZ**2+902.12204*STZ-
0.000164711*STZ**2-0*SKENKEN-41*(1+TRCKENUG)*SKENUG-
36*(1+TRCKENTZ)*SKENTZ-41*(1+TRCKENUG)*SUGKEN-0*SUGUG-
37*(1+TRCUGTZ)*SUGTZ-36*STZKEN-37*(1+TRCUGTZ)*STZUG;

EQUATION2.. PDKEN =E= 431.36 - 0.0000903*DKEN;

EQUATION3..PDUG =E= 1482.8 - 0.003313423*DUG;

Equation4..PDTZ =E= 1213.2 - 0.000360187*DTZ;

Equation5..PSKEN =E= -281.03104+ 0.000142647*SKEN;

Equation6..PSUG =E= -193.9772+ 0.000529978*SUG;

Equation7..PSTZ =E= -902.12204+0.000329422 *STZ;

Equation8..PDKEN - PSKEN =E= 0;

```
Equation9..PDKEN - PDUG =L= 41*(1+TRCKENUG);
Equation10..PDKEN - PDTZ =L= 36*(1+TRCKENTZ);
Equation11..PDUG - PDKEN =L= 41*(1+TRCKENUG);
Equation12..PDUG - PSUG =E=0;
Equation13..PDUG - PDTZ =L= 37*(1+TRCUGTZ);
Equation14..PDTZ - PDKEN =L= 36*(1+TRCKENTZ);
Equation15..PDTZ - PDUG =L= 37*(1+TRCUGTZ);
Equation16..PDTZ - PSTZ =E= 0;
Equation17..SKENKEN + SKENUG + SKENTZ =E=SKEN;
Equation18..SUGKEN + SUGUG + SUGTZ =E=SUG;
Equation19..STZKEN + STZUG + STZTZ =E=STZ;
Equation20..SKENKEN + SUGKEN + STZKEN =E=DKEN;
Equation21..SKENUG + SUGUG + STZUG =E=DUG;
Equation22..SKENTZ + SUGTZ + STZTZ =E=DTZ;
Equation23..TRCKENTZ=E=0.2;
Equation24.. TRCKENUG =E=0.2;
Equation25.. TRCTZKEN =E=0.2;
Equation26.. TRCTZUG =E=0.2;
Equation27.. TRCUGKEN=E=0.2;
Equation28.. TRCUGTZ=E=0.2;
MODEL EASTAFRIC /ALL/;
SOLVE EASTAFRIC USING NLP MAXIMIZING Z;
```

Variables 1 - 30 represent the decision variables in the model. Equation 1 describes the objective function which is maximized subject to constraints in the model. The constraints in the model are represented by equations 2 - 28. Equations 2 – 4 describe the inverse linear demand functions in Kenya, Uganda and Tanzania respectively. Equations 5 - 7 represent the inverse linear supply functions in Kenya Uganda and Tanzania respectively. Equations 8 - 16 describe the spatial equilibrium conditions, equations 17- 19 represent the optimal supply conditions and

equations 20 - 22 represent the optimal demand conditions. Equations 23 - 28 represent the transaction cost. The model is solved using the non linear programming.

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